

Implied monetary policy extracted from interest rate swaps in Chile

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Abstract

This article describes a methodology that uses interest rate swaps in Chilean Pesos to extract monetary policy paths, as well as their probability, with nodes on future Central Bank meetings. It is concluded that implied policy paths contain term premiums that correlate with the policy cycle. Accordingly, implied paths have consistently overestimated the future path of monetary policy, pricing hikes more often than cuts and underestimating the likelihood of rates becoming more expansive. Moreover, the level of implied rates has been governed by the front end of the curve, instead of expectations of the economic cycle. The result is that extracting implied rates from the swap curve is an ineffective tool for forecasting, and that the swap curve has not been able to anticipate changes in policy. These findings provide insights on the asymmetrical risk profile of future monetary policy and may contribute to the design of hedging strategies.

Keywords: monetary policy; interest rate swaps; term premiums; implied rates of monetary policy.

1 Introduction

This article examines a methodology to extract forward looking paths of monetary policy that are implied and can be extracted from the swap curve in Chile. It also

describes the dynamics of implied policy paths and discusses their effectiveness in anticipating changes in monetary policy. The sample is comprised of daily closings for the swap curve (contracts in Chilean Pesos) between January 2011 and December 2017. Up to fifteen months forward implicit rate paths are put to test against actual monetary policy and their dynamics are compared to past and *ex-post* information. It is concluded that implicit rate paths consistently price higher than average monetary policy rates, and that such differences directly correlate with policy cycles which can be interpreted as term premiums. This means that term premiums have been higher during periods of tightening and vice versa. Moreover, the level of fifteen months ahead rates¹ is governed by the front end of the curve and the current level of policy. These findings are contrary to what would be expected for a Central Bank that targets inflation and that normalizes monetary policy once inflation reaches its target.

In the sample period, the variance of the whole path of implied rates is tied to the variance of one month ahead rates. This means that both the level, and the volatility of implied rates are determined by the front end of the curve (both by its level and by its variance). It follows that changes in implied rates are strictly determined and can only be caused by unexpected changes in monetary policy or by the slope of the zero coupon swap curve. It is also concluded that the swap curve is ineffective for pricing one meeting ahead changes in policy, and that it prices hikes more often than it does cuts, contrary to the actual history of monetary policy cycles. In fact, it is shown that the Central Bank has often acted in different ways than the market has been pricing, but that the market has been swift to adapt when surprised. Finally, it is shown that implied monetary policy rates as described in this article have not been able to anticipate future monetary policy and that pricing errors correlate with current monetary policy.

The first part of the article provides a short review of the existing literature regarding expectations of American monetary policy based on the widely used methodologies that rely on Federal Fund Rate Futures. It also looks into literature regarding swaps in Chile and on their proposed uses for extracting future monetary policy expectations. The second part provides a description of the methodology used in this article, as well as a numerical example. In particular, the methodology described projects the underlying index for the netting of plain vanilla interest rate swaps (*índice camara promedio*) and extracts the implicit movements of monetary policy rates and their likelihoods. The third part uses historical data to put to test implicit monetary policy rates against the actual actions taken by the Central Bank and their dynamics are compared to past and *ex-post* information.

¹The rate that is implied for the monetary policy decision fifteen months in the future

2 Literature Review

Most literature focuses on Federal Fund Rate Futures (FFRF) and their use for extracting expectations of FOMC meetings decisions. Nosal et al. (2001) state that as much as FFRF do provide a measure of expected rates in an efficient market, it is sensible for them to price higher rates given the nature of the hedge they provide. For a twelve year sample ending in 2001, they show that FFRF tend to overestimate actual future rates when rates are falling, and underestimate them when they are hiking, or that they fail to interpret the monetary policy cycle. Keasler and Goff (2007) describe in a straightforward fashion a commonly used methodology to extract Fed Fund Rate decisions in upcoming FOMC meetings from interest rate futures. Such methodology is based on the assumptions that *(i)* FFR are always at the target and *(ii)*, FFR can only jump by 25bps.

Similar conclusions are reached by Emmons and Yeager (2002), who determine that FFRF are better at predicting that rates will remain unchanged, and that they tend to predict hikes more often than cuts. Fontaine (2016) shows that volatility in the distribution of expected changes in FFRs depends on the cycle of policy, and that it is lower for tightening cycles. This means that market participants seem more assertive in pricing hikes than cuts.

For the Chilean market, two papers closely examine the underlying methodologies for interest rate swap (IRS). Sotz et al. (2007) describe the functioning of IRS in the local market and how forward rates may be used as proxies for monetary policy expectations. Gana et al. (2007) approach the methodology comprised in this article and focus on the projection of *índice camara promedio*. However, neither works provide a close examination of their effectiveness for pricing implied policy paths.

3 Methodology

An IRS is a derivative contract in which two parties agree to exchange cash flows in the future. A plain vanilla IRS will settle for the accrued interests of a fixed rate and a floating rate (Hull (2003)). Chilean convention for interest rate swaps

is based on an underlying index called *índice camara promedio* (ICP)² which compounds daily average interbank rates (TIB)³ published daily by the Central Bank⁴. The one day composition of ICP is expressed as:

$$ICP_{t,t+1} = ICP_t(1 + TIB_t \times \frac{1}{360}) \quad (1)$$

Expression 1 also refers to weekends and holidays, for which composition is linear. Weekends affect composition positively (for positive rates), but account for minimal differences over a one year period on implicit rates (when rates are small). For the sake of simplicity, this article neglects such convention and thus, expression 1 can be written for any Δ number of days⁵:

$$ICP_{t,t+\Delta} = ICP_t \prod_{i=0}^{\Delta-1} (1 + TIB_{t+i}) \quad (2)$$

Moreover, if the compounding factor (TIB) is a constant, then expression 1 can be written as:

$$ICP_{t,t+\Delta} = ICP_t(1 + TIB_t)^{\frac{\Delta}{360}} \quad (3)$$

which links the interbank rate to the projection of ICP. As described in Gana et al. (2007) and Sotz et al. (2007), the coupon of the floating leg of an IRS will accrue interests daily in accordance with the variation of ICP. In particular, the annualized nominal variation of ICP (TNA)⁶ between any given time t and $t + \Delta$ is defined as:

$$TNA_{t,t+\Delta} = \left(\frac{ICP_{t+\Delta}}{ICP_t} \right)^{\frac{360}{\Delta}} - 1 \quad (4)$$

In fact, ICP is just the average geometric accrued interest of the floating leg of an IRS in pesos. In general, the value of an IRS at the time of its inception is 0 (in absence of transaction costs). Therefore, settlements for a plain zero coupon IRS depend on the difference between the variation of ICP (TNA) and the fixed leg rate. Thus, fixed rates correspond to the expected variation of TNA. It must

²Average swap index

³Average interbank rate - *tasa interbancaria promedio*

⁴If the interbank market does not show any transactions then MPR should be used

⁵For the case of weekends, one could argue that a correction term could be included. The complexity lies on projecting ICP using two separate methods of composition, accounting for weekends and holidays

⁶*Tasa nominal anualizada*. By convention, this rate is rounded to 4 decimal points

therefore hold that for any given maturity Δ , the value of a zero coupon IRS between a fixed rate i and a floating rate TNA will be zero if and only if:

$$ICP_t(1 + i)^{\frac{\Delta}{360}} = ICP_t(1 + TNA)^{\frac{\Delta}{360}} \quad (5)$$

Since, on average, the daily compounding factor of ICP is expected not to deviate from the Central Bank's MPR, it is possible to use expression 5 to extract the implied path of MPR in the swap curve. First, swap curves can be interpolated to obtain rates at maturities that correspond to monetary policy meetings. Secondly, expression 4 is used to obtain the implied rate between meetings. Thirdly, the rate between meetings can be rounded to the nearest quarter of a percentage point, corresponding to monetary policy conventions. This is interpreted as the implied MPR for that maturity.

The aforementioned methodology allows for a defined path of MPR between future monetary policy meetings, a set of implied rates that erase arbitrage for the derivative. Finally, implied probabilities can be obtained in a binary fashion by first, defining whether implied TNA is higher or lower than the previous implied MPR (suggesting a hike or cut in MPR), and then subtracting the rounded rate from the implied TNA and normalizing by a quarter of a percentage point. These probabilities are conditional to the whole path of MPR and cannot be interpreted on their own. The probability of the implied path of MPR is just the joint probability of each event.

Other works in the topic provide a link between forward rates and MPR expectations (Sotz et al. (2007)). In fact, equation 4 is a proxy for forward rates, and it accounts for the exact dates at which monetary policy meetings happen. We refrain from using the term forward rate as this methodology focuses on rounded rates between monetary policy meetings, instead of merely extracting the forward curve. This methodology relies strongly on the slope of swap curves. As a result, swap curves with positive slopes will generally yield implied MPR which are higher than current ones, and vice versa.

3.1 Example

The methodology is best described by the following example. On October 20th 2015, the Central Bank's MPR was set at 3.25%. The 3 month swap rate closed at

3.41% with maturity on January 22nd 2016, or 94 days⁷. The upcoming monetary policy meeting was scheduled for the 12th of November, 23 days further from our initial date, followed by December 17th, January 14th and February 11th, 114 days further.

In this scenario, although the floating leg pegged to the ICP is expected to compound at 3.25% (at the current MPR) for the first 23 days of the contract, the fixed rate would compound at 3.41% (our 3M swap rate) for 23 days, yielding an expected loss for the agent receiving the floating leg⁸. Further, the floating leg would certainly accrue a net loss for the life of the contract if the MPR remained unchanged between meetings. In this simple set up, implied hike expectations come into play, allowing for the possibility of changes in the upcoming four meetings to happen and even out the difference between the fixed and floating legs. The table below depicts the interpolated swap rates (between the current MPR and the 24 month zero coupon swap rate), implied ICP, TIB and MPRs:

Δ Days	Date	Swap interpolation	ICP from swap	Implied TIB	Rounded MPR
-	20-10-2015	3.25	16,687.85	3.25	3.25
23	12-11-2015	3.29	16,721.98	3.41	3.50
58	17-12-2015	3.35	16,776.63	3.50	3.50
86	14-01-2016	3.40	16,821.52	3.57	3.50
114	11-02-2016	3.44	16,867.49	3.65	3.75

Table 1: Implied MPR from swap curve on October 20th 2015.

If future TIBs were exactly what is implied in the swap curve then the value of both legs would be the same. Since MPR is set rounded to the nearest quarter of a percentage point, the difference between implied TIBs and the previous MPR may be interpreted as probabilities. For instance, the 3.41% implied TIB between November 12th and December 17th starting from a known 3.25% MPR means that the probability of a hike on November 12th is defined as:

$$\begin{aligned}
 P(Hike) &= \frac{3.41\% - 3.25\%}{0.25\%} \\
 &= 65\%
 \end{aligned}$$

The fact that MPRs can be increased, decreased or be maintained in each meeting

⁷This is merely a result of conventions. A plain vanilla swap in CLP will start in t+2 working days

⁸Between the beginning of the contract and the first monetary policy meeting, ICP is expected to compound at the current MPR

is eluded by the direction the implied TIB follows, turning our scenario into a binomial problem which allows us to obtain the probability of keeping the rate unchanged⁹. The method can be used to recursively calculate the implied (conditional) probabilities of each MPR decision:

Days	Date	Swap interpolation	Implied TIB	Rounded MPR	P (decrease)	P (maintain)	P (hike)
0	20-10-2015	3.25	3.25	3.25	0%		
23	12-11-2015	3.29	3.41	3.50	0%	35%	65%
58	17-12-2015	3.35	3.50	3.50	0%	100%	0%
86	14-01-2016	3.40	3.57	3.50	0%	72%	28%
114	11-02-2016	3.44	3.65	3.75	0%	40%	60%

Table 2: Implied MPRs and probabilities on October 20th 2015

Finally, the likelihood of occurrence of that particular MPR path is the joint probability of each decision. In this case, the probability of a hike and then maintaining the rate twice, or:

$$\begin{aligned}
 P(path) &= 65\% \times 100\% \times 72\% \\
 &= 47\%
 \end{aligned}$$

which is also interpreted as the likelihood of the swap being worth 0 at maturity. In this scenario, if the MPR remained unchanged until December 17th then it would compound to 16,774.06, and if there was a 25bp hike on November 12th then it would compound to 16,778, which means that:

$$\begin{aligned}
 E_t(ICP_{t+58}) &= P(Hike) \times ICP_{Hike} + P(Maintain) \times ICP_{Maintain} \\
 E_t(ICP_{t+58}) &= 65\% \times 16,778 + 35\% \times 16,774.06,06 \\
 &= 16,776.63
 \end{aligned}$$

this is exactly the ICP we would obtain from interpolating the zero coupon swap curve. The actual path of MPR was:

On November 12th, contrary to what derivatives priced 23 days before, the monetary policy rate was kept unchanged. Since hikes happened less often than what was priced in the three month rate, the payer of the floating leg ended up paying a TNA of 3.40%, or 1bp lower than what was received. The rest of the swap curve was also more hawkish about the next 15 months, where monetary policy rates were expected to reach a terminal level of around 4%. Instead, the Central Bank

⁹This simplification means that we do not need to bother about the likelihood of two equally likely movements of a 25bp hike and a cut

Days	Date	Rounded MPR	Actual MPR	P (maintain)	P (hike)
0	20-10-2015	3.25	3.25	100%	0%
23	12-11-2015	3.50	3.25	35%	65%
58	17-12-2015	3.50	3.50	100%	0%
86	14-01-2016	3.50	3.50	72%	28%
114	11-02-2016	3.75	3.50	40%	60%
149	17-03-2016	3.75	3.50	96%	0%
175	12-04-2016	3.75	3.50	92%	8%
210	17-05-2016	3.75	3.50	68%	32%
240	16-06-2016	4.00	3.50	40%	60%
268	14-07-2016	4.00	3.50	56%	0%
296	11-08-2016	4.00	3.50	60%	0%
331	15-09-2016	4.00	3.50	84%	0%
364	18-10-2016	4.00	3.50	84%	0%
394	17-11-2016	4.00	3.50	88%	0%
420	13-12-2016	4.00	3.50	92%	8%
457	19-01-2017	4.00	3.25	84%	16%
483	14-02-2017	4.00	3.25	64%	36%
513	16-03-2017	4.00	3.00	52%	48%

Table 3: Implied MPRs and probabilities on October 20th 2015

cut rates to 2.50% after many months of economic slack and low inflation. This would have seemed odd to an investor that had observed average rates of 3.98% since 2008¹⁰.

In the following section the following questions are addressed; how often do investors lose when betting on a MPR path? How does the market react when it fails to predict a change in monetary policy? If market participants are unable to properly price future paths of MPR, is there a specific direction for these errors? Can this methodology be used to extract measures of term premiums? And finally, can such term premiums be quantified in order to better understand the transmission of monetary policy?

4 Data and results

With the aforementioned methodology, it is possible to extract implied monetary policy rate paths using daily closings for the swap curve and the known dates of central bank meetings. Accordingly, it is also possible to obtain the probability of hikes, analyze the dynamics of expectations, the degree of response of MPR expectations to relevant information and assess the overall predictive power of the swap curve to MPR decisions.

Ex-post known meeting dates can be used without loss of generality since their monthly frequency has been consistent. In this section, daily observations between January 2011 and August 2017 for the zero coupon swap curve at maturities of 3, 6, 9, 12 and 18 months are used, as well as actual monetary policy rates in order to compare 15 months ahead implied rates. The choice of ending the sample in September 2017 is due to the change in the frequency of policy meetings from 12 to 8 starting in 2018. The would have been future monthly dates of meetings up to August 2017 is estimated following historical dates.

4.1 Swap curves between 2011 and 2017

Table 4 summarizes daily swap and monetary policy rates between 2011 and 2017. It also shows the average difference between 18 month swaps and MPRs, as well as their standard deviations. One and a half year swap rates tend to be higher than MPRs by an average of 8bps. In three out of seven years, average swap rates

¹⁰Including a 10 month period of rates at 0.5% in 2009

showed an upward slope, with an average difference of 33bps. In the four years of negative slopes, two of them constitute the highest average MPRs in the sample (suggesting a period of tightening monetary policy). Since zero coupon swap rates refer to implied future policy rates, average differences are interpreted as pure term premiums. Such premiums' variability is constant over the sample, with the exception of 2011. If instead of the 18 month rate the 24 month zero coupon rate is used results are similar.

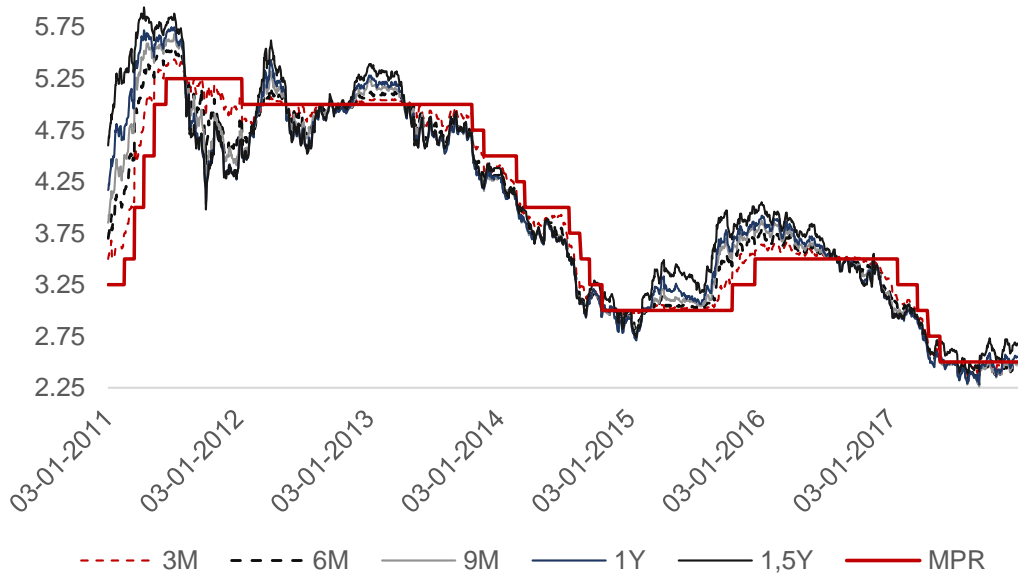


Figure 1: Swap curves between January 2011 and December 2017

	MPR	3M	6M	9M	12M	18M	18M - MPR	SD (18M - MPR)
2011	4.68	4.83	4.89	4.95	5.00	5.15	0.47	1.08
2012	5.01	4.96	4.93	4.92	4.92	4.97	- 0.03	0.30
2013	4.92	4.85	4.79	4.77	4.77	4.82	- 0.10	0.27
2014	3.74	3.60	3.52	3.50	3.49	3.54	- 0.21	0.18
2015	3.06	3.14	3.21	3.26	3.32	3.46	0.40	0.28
2016	3.50	3.53	3.53	3.54	3.56	3.61	0.11	0.25
2017	2.73	2.64	2.60	2.58	2.59	2.68	- 0.05	0.20
Total	3.95	3.93	3.92	3.93	3.95	4.03	0.08	0.53

Table 4: Summary of average policy and swap rates between 2011 and 2017

4.2 Monetary policy rates and average interbank rates

For a better characterization of monetary policy cycles and their effect on implied MPR paths it is convenient to study past policy. Between 2007 and 2017, monetary policy target rates achieved their maximum and minimum levels both before and after the global economic downturn of 2008 and 2009 (figure 2). Target rates average 3.95% with a median of 4% and they have stayed between 2.50% and 6.50% over 80% of the time. During our sample period of 2011 to 2017, MPRs were always bounded by those limits.

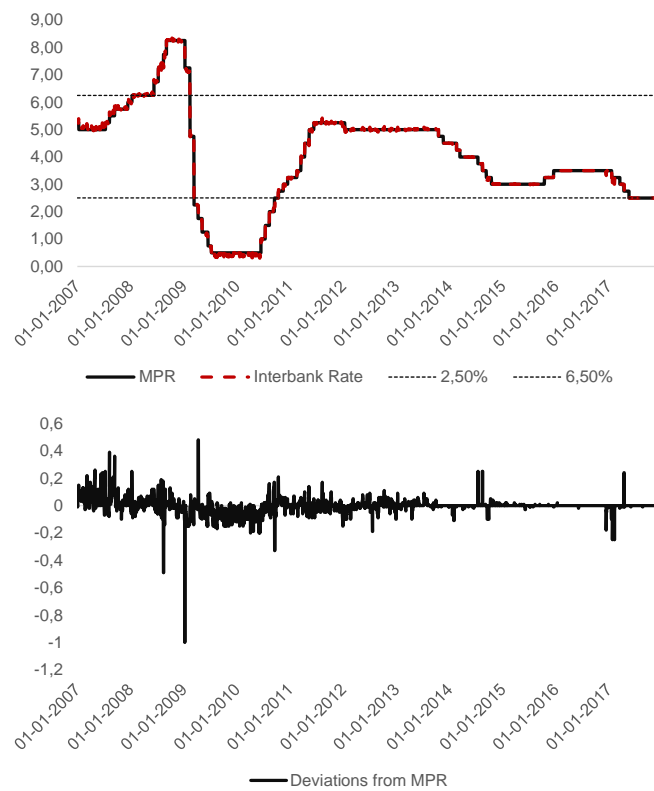


Figure 2: Monetary policy rates and average interbank rates

Our sample period of 2011 to 2017 shows an increase of MPR from 3.25% to 5.25%, following repeated hikes since the near zero levels of 2009. Between 2011 and 2013, MPR was kept between 5% and 5.25% for a total of 900 days, after which MPR

was cut to levels that average 3.30%¹¹. In fact, both during 2015, and since 2017, monetary policy has been expansionary, keeping MPR at 3% for one year in the period between October 2014 and October 2015, and at 2.50% for the second half of 2017¹². Between 2011 and 2017, 20 changes in MPR have taken place, 17 of which were of a 25bp magnitude, seven of which have been hikes (including three hikes of 50bps), and 13 have been cuts (all of them of 25bps). Table 5 shows that cuts are more common than hikes (even if hikes of 50bps are counted twice), reflecting the expansionary nature of the sample period. Accordingly, 2011 and 2015 are years of at least partially tightening monetary policy given that hikes took place then, whereas the rest are years of looser monetary policy.

	Number of times the CB acted			
	Cut	No change	Hike	MPM
2011	0	7	5	12
2012	1	11	0	12
2013	2	10	0	12
2014	6	6	0	12
2015	0	10	2	12
2016	0	12	0	12
2017	4	8	0	12
Total	13	64	7	84

Table 5: Monetary policy meetings between 2011 and 2017

With respect to *indice camara promedio*, daily interbank rates (TIB) average no statistically significant deviations from monetary policy rates. Such differences have in fact grown smaller since 2013. Finally, the Central Bank tends to provide forward guidance and policy cycles should be, to some extent, expected by market participants. As it will be shown, MPR paths do depend on the current cycle of monetary policy. With respect to the ultimate goal of monetary policy, inflation has mostly stayed anchored to its 3% target since 2011.

4.3 Implied monetary policy rate paths

In this section daily implied monetary policy paths between 2011 and August 2017 are calculated. From table 4, it is expected that positive average term premiums

¹¹This hike cycle coincides with the higher variability of the premium of 18 month swaps compared to policy rates

¹²And until October 2018 when the target rate was moved to 2.75%

would yield upward sloping MPR paths, but with varying levels for terminal rates at 18 months. Figure 3 shows that average implied rates have an upward slope at maturities over 6 months, suggesting that policy cuts are only priced for the near horizon. This is sensible given that most of the sample was taken in a generally expansionary cycle of monetary policy (3M swap rates were lower than MPRs 60% of the time, and are 2bps lower on average).

On the other hand, average fifteen month ahead implied MPRs are higher than actual target rates, corresponding to the higher average levels of 18M swaps. The expansionary nature of monetary policy during the sample period is also shown by the fact that 18M swaps are lower than MPRs 51% of the time, suggesting that when priced in, implied hike paths would be steep. In fact, the change in the one month premium has a positive slope (figure 4).

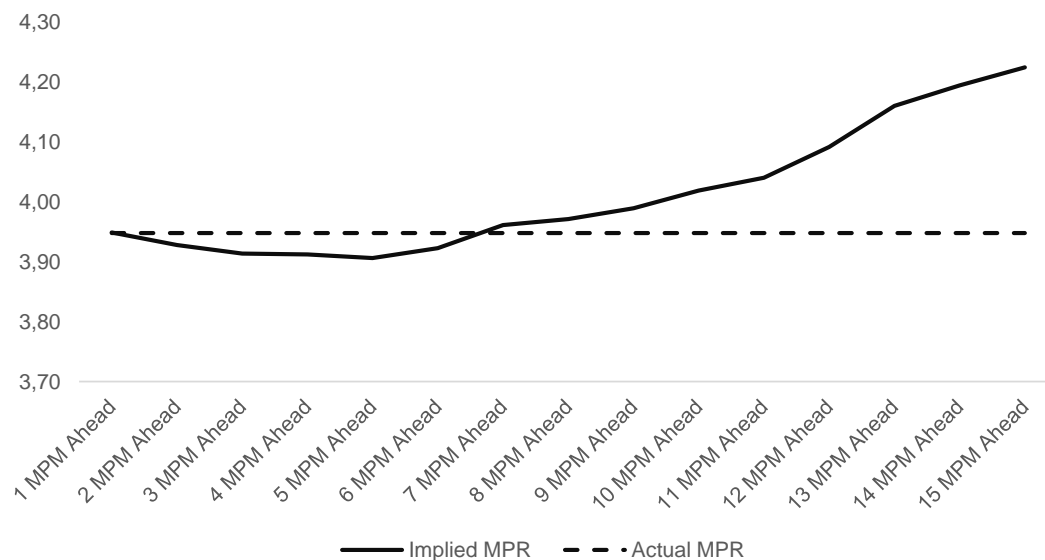


Figure 3: Upward sloping average implied monetary policy rates

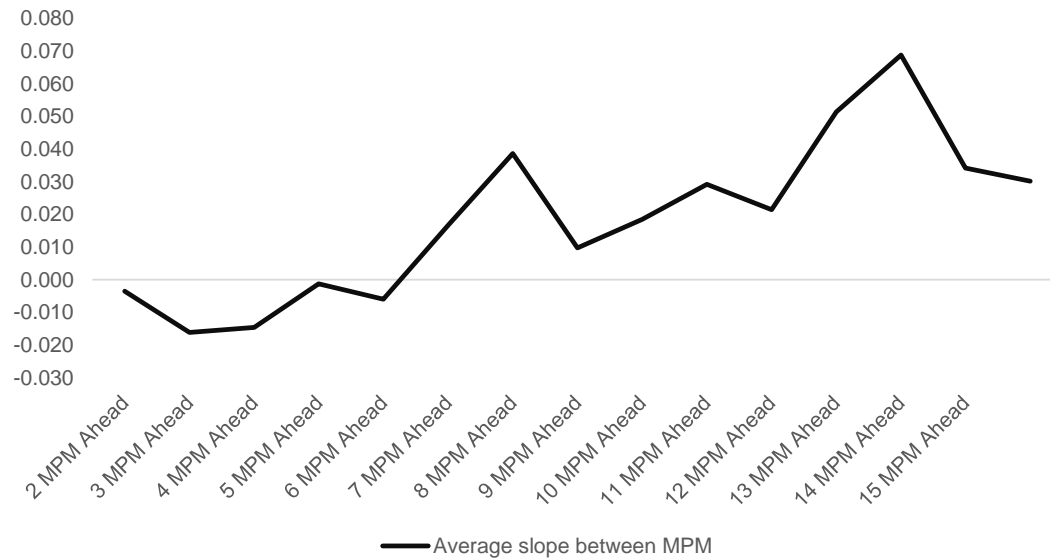


Figure 4: Average slope of implied monetary policy rates between meetings

	Cut cycle	Whole series	Hike cycle
2011	-3.1	3.1	7.1
2012	-1.6	0.3	1.3
2013	-1.2	0.0	1.0
2014	-1.3	-0.4	0.5
2015	-1.0	2.8	2.9
2016	-1.1	0.8	1.3
2017	-1.2	0.0	0.6
All	-1.5	0.9	2.1

Table 6: Average number of implied hikes/cuts between 2011 and 2017 (15 months ahead)

Table 6 represents hikes with a positive sign and cuts with a negative sign. The average number of hikes fifteen months ahead is 0.9 and it is only negative in one year of the sample, whereas the number reaches 2.1 during hike only cycles¹³. On the other hand, an average of 1.5 cuts were priced in, regardless of the fact that monetary policy was expansive more often than it was contractive. In the tightening years of 2011 and 2015, implied MPRs were priced accordingly, but the same cannot be said of the rest. In fact, as table 7 shows, the upward sloping term structure of implied rates is almost always positive (the average slope of 15

¹³According to the implied rate one meeting ahead, ie. if the likelihood of a hike/cut is higher than 50%

MPM ahead rates is 25bps), while standard deviations of implied MPR paths are roughly equal for longer maturities. This suggests that all variability in the level of implied rates is due to variability in the front end of the curve. Further, in our sample, implied policy rates oscillate around the moving average mean of MPRs since 2007, reinforcing that medium term implied rates depend more on spot rates rather than policy cycles (figure 5).

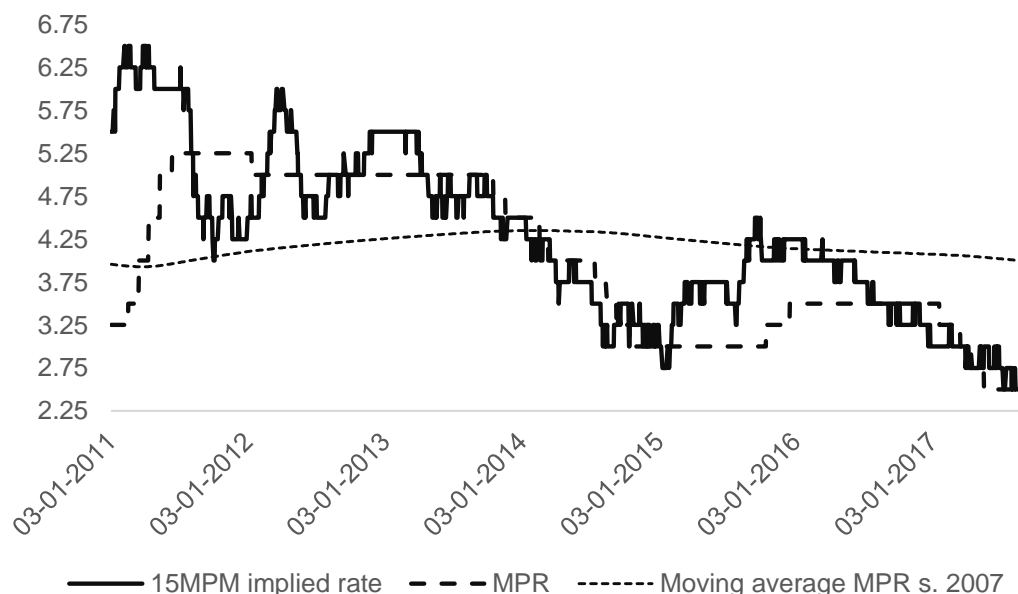


Figure 5: 15 Month ahead implied MPR vs. actual and average MPR.

Implied future rates show persistence and they are anchored to current rates. Table 8 shows that there is a positive correlation between overnight current MPRs and future ones (the average level of MPR and 15 month ahead implied rates show a correlation of 0.96). This means that periods of high average monetary policy rates such as 2011 and 2012 exhibit higher implied terminal rates, and periods of low inflation and low rates like 2016 and 2017 show lower terminal rates.

In our sample, hike and cut cycles are persistent and a hike is more likely after one has taken place (table 5 shows that cuts and hikes “cluster”). As seen before, not all monetary policy cycles are the same, and often the level of implied terminal rates depends on forward guidance and changing macroeconomic dynamics. The “scenario” variable in table 9 assigns a 1 to expected hikes, a -1 to cuts and a 0 when rates are expected to remain unchanged¹⁴. The table suggests that there is a positive correlation between current policy cycles and the path of implied future

¹⁴In the next policy meeting

rates, and that average accumulated month to month premiums are higher for more hawkish scenarios and viceversa.

The fact that some periods show higher term premiums, and that average implied rates differ greatly from actual policy rates, suggests that extracting policy paths from swap curves is an ineffective tool. Fifteen month ahead implied rates are dependent on the level of current MPR, and not on expectations for the economic cycle. If implicit monetary policy rates are unbiased and merely the result of market expectations, then average implicit rates should not differ much from actual rates, even if the shape of their path does not correspond to actual future events. Instead, we see a premium between medium and short term implied rates.

Monetary policy decisions are taken on the basis of price stability pursuing an inflation target of 3% but past inflation history shows a high degree of reversion towards the CB target, and so do actual monetary policy rates, reverting towards lower levels as inflation approaches its target. Evidence has been shown to support that the opposite happens with implied policy paths as medium term rates co-move with current MPR cycles, instead of showing pure expectations.

MPM Ahead	1 MPM	2 MPM	3 MPM	4 MPM	5 MPM	6 MPM	7 MPM	8 MPM	9 MPM	10 MPM	11 MPM	12 MPM	13 MPM	14 MPM	15 MPM
Implied MPR	4.01	4.00	3.98	3.98	3.98	3.99	4.03	4.03	4.05	4.07	4.08	4.13	4.21	4.24	4.26
SD	0.89	0.90	0.90	0.89	0.92	0.93	0.93	0.95	0.96	0.96	0.98	0.98	0.95	0.96	0.97
Max	5.50	5.50	5.50	5.75	6.00	6.00	6.00	6.00	6.25	6.25	6.50	6.50	6.25	6.25	6.50
Min	2.50	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.50	2.50	2.50
One month premium		-0.02	-0.01	0.00	-0.01	0.02	0.04	0.01	0.01	0.02	0.01	0.05	0.08	0.03	0.03
Accumulated premium		-0.02	-0.03	-0.03	-0.04	-0.02	0.01	0.02	0.03	0.06	0.06	0.11	0.19	0.22	0.25

Table 7: Summary statistics for *implied monetary policy rates* in upcoming monetary policy meetings

MPM Ahead	MPR	1 MPM	2 MPM	3 MPM	4 MPM	5 MPM	6 MPM	7 MPM	8 MPM	9 MPM	10 MPM	11 MPM	12 MPM	13 MPM	14 MPM	15 MPM
2011	4.67	4.77	4.87	4.92	4.91	4.96	5.00	5.05	5.10	5.13	5.15	5.18	5.26	5.35	5.40	5.45
2012	5.01	4.99	4.95	4.91	4.90	4.87	4.89	4.91	4.91	4.91	4.93	4.91	4.95	5.02	5.05	5.07
2013	4.92	4.89	4.81	4.76	4.75	4.73	4.76	4.76	4.75	4.75	4.77	4.78	4.83	4.90	4.91	4.92
2014	3.76	3.68	3.58	3.48	3.49	3.41	3.41	3.46	3.44	3.45	3.49	3.48	3.53	3.61	3.63	3.64
2015	3.06	3.10	3.14	3.19	3.23	3.26	3.30	3.36	3.40	3.42	3.47	3.50	3.56	3.64	3.71	3.75
2016	3.50	3.50	3.52	3.55	3.53	3.53	3.55	3.58	3.57	3.59	3.61	3.62	3.64	3.67	3.69	3.70
2017	2.85	2.79	2.71	2.64	2.66	2.65	2.64	2.63	2.60	2.59	2.61	2.60	2.66	2.81	2.83	2.86

Table 8: Summary of yearly *average implied monetary policy rates* in upcoming monetary policy meetings

	1 MPM	2 MPM	3 MPM	4 MPM	5 MPM	6 MPM	7 MPM	8 MPM	9 MPM	10 MPM	11 MPM	12 MPM	13 MPM	14 MPM	15 MPM	Average	MPM Cycle
2011	0.11	0.20	0.25	0.25	0.30	0.33	0.38	0.43	0.47	0.49	0.52	0.60	0.68	0.73	0.78	0.43	0.4
2012	-0.02	-0.06	-0.10	-0.11	-0.14	-0.12	-0.09	-0.10	-0.10	-0.08	-0.10	-0.06	0.01	0.04	0.06	-0.06	-0.1
2013	-0.04	-0.11	-0.16	-0.17	-0.20	-0.20	-0.17	-0.18	-0.17	-0.16	-0.15	-0.09	-0.03	-0.01	-0.01	-0.12	-0.2
2014	-0.08	-0.18	-0.28	-0.27	-0.34	-0.35	-0.29	-0.31	-0.30	-0.27	-0.27	-0.23	-0.14	-0.13	-0.11	-0.24	-0.3
2015	0.04	0.08	0.13	0.17	0.20	0.24	0.30	0.34	0.36	0.41	0.44	0.50	0.58	0.65	0.69	0.34	0.2
2016	0.00	0.02	0.05	0.03	0.03	0.05	0.08	0.07	0.09	0.11	0.12	0.14	0.17	0.19	0.20	0.09	0.0
2017	-0.05	-0.14	-0.20	-0.19	-0.20	-0.21	-0.22	-0.25	-0.25	-0.24	-0.25	-0.19	-0.04	-0.01	0.01	-0.16	-0.2

Table 9: Summary of yearly *average accumulated implied MPR premiums* in upcoming monetary policy meetings

4.4 Implied probabilities one meeting ahead

Implied probabilities also matter since the slope of the curve will affect not only terminal rates but also the likelihood of each scenario. The monetary policy meeting regime remained unchanged in its monthly frequency until the end of 2017, allowing for the use of the full sample of 2017 rates. On the day of monetary policy meeting, only 5 times in 2011 and 2 times in 2014 was the Central Bank expected to do something other than keeping their target rate unchanged. Table 10 shows the average probability of monetary policy changes of 25bps on each day of monetary policy meetings given the most likely scenario. As seen on the under-representation of the number of times the market priced hikes/cuts and their likelihood compared to keeping rates unchanged, the market is more decisive at pricing hikes than cuts, and certainly more decisive at pricing that rates will remain unchanged. This means that the market was incorrect even when pricing the next policy decision since changes happened more often than what was priced.

	Number of times CB was expected to			Implied probabilities		
	Cut	Maintain	Hike	Cut	Maintain	Hike
2011	0	7	5		75%	69%
2012	0	12	0		90%	
2013	0	12	0		86%	
2014	2	10	0	56%	76%	
2015	0	12	0		87%	
2016	0	12	0		91%	
2017	0	12	0		83%	

Table 10: Average implied probability of cuts and hikes on the day of each monetary policy meeting

In fact, table 11 shows that almost every time rates were changed (with the exception of 2011), the market was surprised by the decision taken by the Central Bank.

Implied changes in the target rate for the upcoming meeting are strictly governed by the 3M swap rate, a rather illiquid contract in nature. Going back to table 4, 3M rates are very close in level to monetary policy rates, indicating that implied changes would be rare. However, illiquidity is not enough to explain the inability of the 3M contract to properly price policy decisions, especially since rates are interpolated in absence of actual transactions, and therefore should reflect prices more accurately through contracts with longer maturities. Moreover, 3M swaps are generally used as benchmarks (and hedges) for more actively traded securities such as bank deposits or currency forwards.

	Policy decisions			Implied probabilities		
	Cut	Maintain	Hike	Cut	Maintain	Hike
2011	0	7	5		74%	66%
2012	1	11	0	28%	92%	
2013	2	10	0	18%	86%	
2014	6	6	0	44%	85%	
2015	0	10	2		91%	32%
2016	0	12	0		91%	
2017	4	8	0	34%	93%	

Table 11: Average implied probability of cuts and hikes when the Central Bank acted

In short, the inability of the curve to anticipate policy changes should not be attributed to the illiquidity of the short end of the curve. In fact, the findings in this section correspond to those of the previous one. The over representation of hikes has to do with the slope of the curve which is generally positive, and the under representation of cuts corresponds to a period of monetary policy that repeatedly became more expansive. Similarly, findings for longer implied rates also suggest that they exceed actual rates, supporting the idea that there is, in fact, a premium in implied rates from actual monetary policy. In the next section, those term premiums will be quantified.

5 Backtesting and dynamics of implied rates

Implied paths can be tested against actual policy rates. In this section, we turn back to the shortened sample (up to August 2017). As suggested, implied rates are on average different (higher), from actual rates. A pricing error is defined as the difference between the actual rate that was implicit for any given date and the actual rate.

Table 12 shows yearly average pricing errors. Absolute one to eight month ahead errors are close to zero whereas for longer maturities they increase. In fact, for all seven years of the sample, average pricing errors for maturities longer than 12 months are strictly negative. This means that the market overpriced the implied path MP would take. On average, the market mispriced implied 15 month ahead rates by 66bps, reaching maximums of 200bps in September 2013 when the market failed to price that MPRs would fall from 5% to 3%. Correlation between MPRs and pricing errors is -0.84, meaning that higher rates lead to higher errors, which is consistent with the fact that average terminal rates differ from average actual

rates. In short, the market prices poorly the future path MPR will take, so poorly that implied paths do not even correlate with historical information of policy rates.

Errors for up to 8 MPM ahead are small regardless of how poorly the market prices one meeting ahead decisions. This is explained by the fact that for most of the time, rates remain unchanged, and that when surprised, the market adapts its view to new information.

Table 13 shows all monetary policy meetings between 2011 and August 2017, as well as the spot implied MPR one meeting ahead and their implied probabilities. Surprises are marked with a 1 when actual policy decisions were different than what was priced in. The change in probabilities refers to the difference in the probability of maintaining MPR between the following and the current meeting, after a surprise happened.

When the market is surprised, one of two things happens; either swap rates react to the surprise by shifting to a new level, or by increasing the likelihood of any given movement. In most cases, implied probabilities jump to adapt new information. In fact, the average (absolute value) jump in probabilities of a hike or a cut when the market is surprised is 17%, compared to the 7% when it is not surprised. This shows that the market reacts to new information after a policy meeting. In particular it is observed that the month to month (meeting to meeting) standard deviation of monetary policy changes is 9bps for the month after a surprise compared to 4bps when it is not.

It is interesting that surprises “cluster” in the first months before a switch in policy cycles, after which implied rates adapt to better interpret CB future decisions. The main conclusions to be drawn here is that the market is usually right when it prices that rates will stay unchanged, and they do most of the time. However, when policy cycles change, they do so suddenly and surprise the market, that reacts to said information and improves its pricing.

Pricing error	1 MPM	2 MPM	3 MPM	4 MPM	5 MPM	6 MPM	7 MPM	8 MPM	9 MPM	10 MPM	11 MPM	12 MPM	13 MPM	14 MPM	15 MPM	Average
2011	0.05	0.09	0.14	0.21	0.19	0.14	0.06	- 0.00	- 0.06	- 0.10	- 0.15	- 0.26	- 0.35	- 0.40	- 0.45	- 0.06
2012	0.01	0.05	0.09	0.10	0.13	0.11	0.09	0.09	0.09	0.06	0.04	- 0.03	- 0.14	- 0.22	- 0.32	0.01
2013	- 0.01	0.01	- 0.01	- 0.08	- 0.14	- 0.22	- 0.35	- 0.45	- 0.58	- 0.75	- 0.89	- 1.07	- 1.27	- 1.40	- 1.50	- 0.58
2014	- 0.05	- 0.07	- 0.06	- 0.15	- 0.16	- 0.24	- 0.37	- 0.40	- 0.44	- 0.47	- 0.46	- 0.46	- 0.51	- 0.48	- 0.46	- 0.32
2015	-	0.01	- 0.01	0.01	0.02	0.01	- 0.00	- 0.01	0.02	- 0.00	- 0.01	- 0.06	- 0.15	- 0.24	- 0.31	- 0.05
2016	- 0.01	- 0.05	- 0.11	- 0.14	- 0.22	- 0.31	- 0.42	- 0.51	- 0.61	- 0.71	- 0.81	- 0.91	- 1.02	- 1.10	- 1.17	- 0.54
2017	- 0.06	- 0.07	- 0.08	- 0.14	- 0.15	- 0.14	- 0.13	- 0.10	- 0.09	- 0.11	- 0.10	- 0.16	- 0.31	- 0.33	- 0.36	- 0.15
Average	- 0.01	0.00	- 0.00	- 0.02	- 0.04	- 0.09	- 0.16	- 0.20	- 0.24	- 0.30	- 0.34	- 0.43	- 0.54	- 0.60	- 0.66	
SD	0.11	0.16	0.22	0.28	0.33	0.37	0.40	0.44	0.49	0.54	0.61	0.63	0.62	0.65	0.68	
Max	0.25	0.75	0.75	1.00	1.25	1.25	1.25	1.50	1.50	1.25	1.50	1.50	1.00	1.00	1.00	
Min	- 0.25	- 0.50	- 0.50	- 0.75	- 0.75	- 1.00	- 1.00	- 1.00	- 1.25	- 1.50	- 1.50	- 1.50	- 2.00	- 2.00	- 2.00	

Table 12: Summary of yearly average pricing errors for implied policy paths

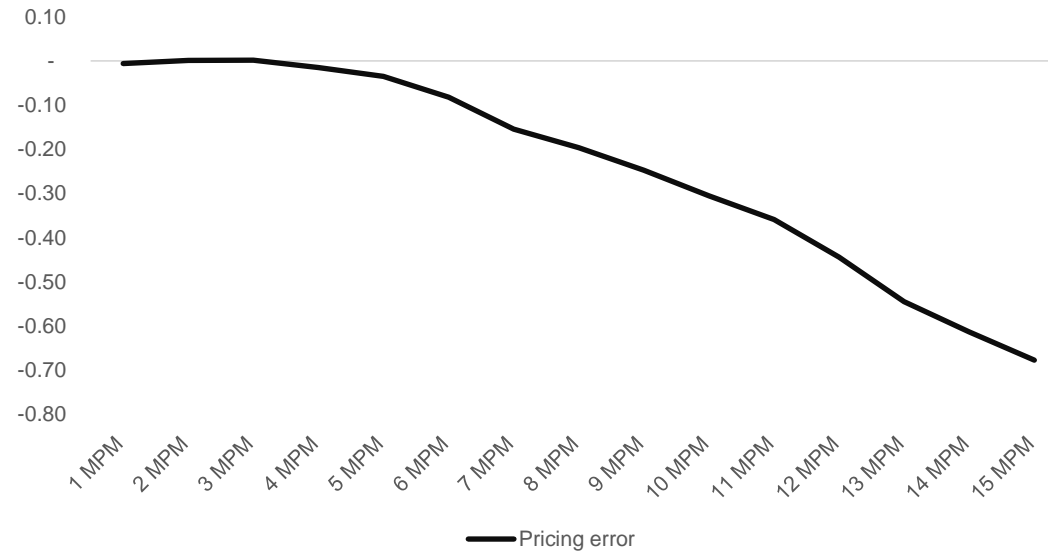


Figure 6: Average pricing error of implied policy paths

Date of MPM	Monetary policy decisions			One MPM ahead probabilities (%)			Surprise measures	
	MPR	Implied MPM	Actual decision	Cut	Maintain	Hike	Surprise	Change in probs (%)
13-01-2011	3.25	3.5	3.25	-	44	56	1	0
17-02-2011	3.25	3.5	3.5	-	44	56	-	
17-03-2011	3.5	3.75	4	-	40	60	1	40
12-04-2011	4	4.25	4.5	-	0	100	1	-28
12-05-2011	4.5	4.75	5	-	28	72	1	-28
14-06-2011	5	5	5.25	-	56	44	1	-24
14-07-2011	5.25	5.25	5.25	-	80	20	-	
18-08-2011	5.25	5.25	5.25	12	88	-	-	
15-09-2011	5.25	5.25	5.25	4	96	-	-	
13-10-2011	5.25	5.25	5.25	24	76	-	-	
15-11-2011	5.25	5.25	5.25	24	76	-	-	
13-12-2011	5.25	5.25	5.25	44	56	-	-	
12-01-2012	5.25	5.25	5	28	72	-	1	0
14-02-2012	5	5	5	28	72	-	-	
15-03-2012	5	5	5	-	96	4	-	
17-04-2012	5	5	5	-	92	8	-	
17-05-2012	5	5	5	4	96	-	-	
14-06-2012	5	5	5	12	88	-	-	
12-07-2012	5	5	5	24	76	-	-	
16-08-2012	5	5	5	4	96	-	-	
13-09-2012	5	5	5	-	100	-	-	
18-10-2012	5	5	5	-	100	-	-	
13-11-2012	5	5	5	4	96	-	-	
13-12-2012	5	5	5	-	96	4	-	
17-01-2013	5	5	5	-	96	4	-	
14-02-2013	5	5	5	-	96	4	-	
14-03-2013	5	5	5	-	96	4	-	
11-04-2013	5	5	5	-	96	4	-	
16-05-2013	5	5	5	16	84	-	-	
13-06-2013	5	5	5	24	76	-	-	
11-07-2013	5	5	5	16	84	-	-	
13-08-2013	5	5	5	24	76	-	-	
12-09-2013	5	5	5	16	84	-	-	
17-10-2013	5	5	4.75	12	88	-	1	12
19-11-2013	4.75	4.75	4.5	24	76	-	1	0
12-12-2013	4.5	4.5	4.5	24	76	-	-	
16-01-2014	4.5	4.5	4.5	28	72	-	-	
18-02-2014	4.5	4.5	4.25	32	68	-	1	
13-03-2014	4.25	4.25	4	44	56	-	1	-24
17-04-2014	4	4	4	20	80	-	-	
15-05-2014	4	4	4	12	88	-	-	
12-06-2014	4	4	4	16	84	-	-	
15-07-2014	4	4	3.75	40	60	-	1	20
14-08-2014	3.75	3.5	3.5	60	40	-	-	
11-09-2014	3.5	3.25	3.25	52	48	-	-	
16-10-2014	3.25	3.25	3	36	64	-	1	-32
18-11-2014	3	3	3	-	96	4	-	
11-12-2014	3	3	3	8	92	-	-	
15-01-2015	3	3	3	4	96	-	-	
12-02-2015	3	3	3	-	100	-	-	
19-03-2015	3	3	3	-	96	4	-	
16-04-2015	3	3	3	-	96	4	-	
14-05-2015	3	3	3	-	96	4	-	
11-06-2015	3	3	3	-	96	4	-	
14-07-2015	3	3	3	-	100	-	-	
13-08-2015	3	3	3	-	96	4	-	
15-09-2015	3	3	3	-	72	28	-	
15-10-2015	3	3	3.25	-	64	36	1	0
12-11-2015	3.25	3.25	3.25	-	64	36	-	
17-12-2015	3.25	3.25	3.5	-	72	28	1	-16
14-01-2016	3.5	3.5	3.5	-	88	12	-	
11-02-2016	3.5	3.5	3.5	-	80	20	-	
17-03-2016	3.5	3.5	3.5	-	84	16	-	
12-04-2016	3.5	3.5	3.5	-	92	8	-	
17-05-2016	3.5	3.5	3.5	-	92	8	-	
16-06-2016	3.5	3.5	3.5	-	96	4	-	
14-07-2016	3.5	3.5	3.5	-	96	4	-	
11-08-2016	3.5	3.5	3.5	-	100	0	-	
15-09-2016	3.5	3.5	3.5	-	100	0	-	
18-10-2016	3.5	3.5	3.5	4	96	-	-	
17-11-2016	3.5	3.5	3.5	8	92	-	-	
13-12-2016	3.5	3.5	3.5	24	76	-	-	
19-01-2017	3.5	3.5	3.25	44	56	-	1	-20
14-02-2017	3.25	3.25	3.25	24	76	-	-	
16-03-2017	3.25	3.25	3	28	72	-	1	12
13-04-2017	3	3	2.75	40	60	-	1	-16
18-05-2017	2.75	2.75	2.5	24	76	-	1	-20
15-06-2017	2.5	2.5	2.5	4	96	-	-	
13-07-2017	2.5	2.5	2.5	12	88	-	-	
17-08-2017	2.5	2.5	2.5	8	92	-	-	

Table 13: Monetary policy decisions and their probabilities

In short, the market is often surprised when rates are changed. In 20 meetings that concluded in hikes or cuts, the market was surprised 15 times¹⁵. As seen before, the market was surprised more often when cuts took place, and only twice did it properly price cuts. When it was not surprised, the market only expected the change with a 56% probability. When it was surprised, the market expected the change with a 72% probability. This means, that if the Central Bank monitors average implied rates extracted from swap rates, it has no problem with surprising the market, or fails to actively communicate intended changes.

Since one month ahead policy decisions are extracted from interpolated rates, it may very well be that the slope of the curve is not steep enough to anticipate changes. Instead, the board of the Central Bank may focus on surveys rather than implied prices and agents may not actively trade three month swaps as much as longer maturities. In fact, absolute pricing errors negatively correlate with periods of steeper curves and are smaller when it comes to anticipating hikes, but the same is not true regarding cuts, and negative slopes are less frequent. In any case, the general lack of predictive power for the curve and its bias to price hikes correlates with its medium term structure.

6 Conclusion

It is concluded that the paths of monetary policy rates that are implied in swap rates are usually different (higher by 25bps) than actual monetary policy rates. This means that, on average, medium term swap rates (up to 15 months) contain a term premium that is quantifiable and depends on the cycle of monetary policy. In fact, hike cycles, defined as the period in which the slope of the curve is steep enough to justify increases in upcoming monetary policy rates show an average of 2.1 hikes of 25bps in 15 months. Accordingly, cut cycles show 1.5 cuts, whereas the whole series shows 0.9 hikes, regardless of the fact that cuts happened twice as often as hikes.

The difference in the number of implied movements for different cycles is significant. In fact, it is shown that there exists a positive correlation between current policy cycles and the path of implied future rates, and that average accumulated month to month premiums are higher for more hawkish scenarios and vice versa. It is also concluded that in a world where monetary policy generally reverts to

¹⁵In three occasions, the market was not surprised in the direction but in the magnitude. This means that the total number of surprises was 18

the mean, swap curves strictly price hikes for the medium term whereas cuts are only priced for the first six months of the implied path. Moreover, on average, the market mispriced 15 month ahead rates. In particular periods, pricing errors are significant and fail to recollect past information on monetary policy rates.

This article also looked at the probability of changes for the short end of the implied path of policy rates. By extracting one month ahead probabilities of policy decisions it is shown that even if hikes happen much less often than cuts, they are priced much more often. This difference is so dramatic, that in all of our sample, the market was generally surprised before cuts happened, and was uncertain when hikes happened. This may be explained by the slope of the curve rather than by arbitrage measures for three month swaps. In any case, we have shown that swap rates are an ineffective tool to extract future monetary policy rates, and that they are particularly ineffective to price expansionary cycles of monetary policy.

More research is needed to identify the nature behind the term premiums existing in the curve of implied monetary policy rates and on the nature of the term premium component of the slope of the swap curve in general. Finally, further work on the subject of implied monetary policy will determine if the change in monetary policy meetings regime had any effect on improving the pricing of future policy paths, or even reducing the variability of said paths.

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