Computing long-term market inflation expectations for countries without inflation expectation markets

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Abstract

We derive daily market-based domestic long-term inflation expectations for eight countries without inflation swap markets. To do so, we use foreign inflation swaps together with (1) foreign and domestic interest rate swaps assuming that purchasing power parity (PPP) and uncovered interest rate parity (UIP) hold or together with (2) spot and forward exchange rates assuming that PPP, UIP and covered interest rate parity (CIP) hold. We confirm the plausibility of our PPP-UIP and PPP-UIC-CIP measures by also applying these methods for countries with inflation swap markets. We moreover illustrate how the data can be used to answer such questions as whether inflation reacts to long-term inflation expectations, whether these expectations are well-anchored and how long-term real interest rates have moved over the past decade.

Key words: Inflation expectations, market-based inflation expectations, anchoring of inflation expectations, long-term real interest rates

JEL classification: E31, E44, E58.

1. Introduction

Markets and central banks alike monitor long-term inflation expectations. Markets monitor inflation expectations because they give an indication of how expected nominal returns need to be adjusted to gain a sense of future real returns. Central banks monitor inflation expectations because they reflect how credible policymakers promise to keep inflation stable and close to the desired level. In general, credible central banks find it easier to maintain price stability than those with low credibility because of the stabilising effect of well-anchored inflation expectations.

There are two basic kinds of measure for inflation expectations: Survey-based data and market data. Surveys are conducted among professional forecasters, firms or households. Market data on inflation expectations come in two varieties, namely, as inflation swaps, which measure expectations directly, and as the difference in yields of nominal and inflation-linked bonds.

Survey and market expectations have both advantages and disadvantages. Surveys for long-term inflation expectations typically cover a long period of time and are mostly conducted on a quarterly or half-yearly basis. Market data are available essentially continuously but often do not reach far into the past. Market expectations reflect actual positions taken by market participants, whereas survey respondents have no money to lose. Household surveys may be more backward-looking than financial market expectations. Finally, both surveys and market data may be affected by small sample problems: for surveys, the number of participants may be low, for market data, liquidity may be low.

Indeed, for some countries, there is no market for inflation expectations at all. This paper shows how to compute market-based long-term inflation expectations for those countries all the same. To do so, we use foreign inflation swaps together with (1) foreign and domestic interest rate swaps assuming that purchasing power parity (PPP) and uncovered interest rate parity (UIP) hold, or together with (2) spot and forward exchange rates assuming that PPP, UIP and covered interest rate parity (CIP) hold. We concentrate on 5y/5y forward inflation expectations, which is the measure commonly used to gauge a central bank's credibility. Of course, this method could also be used to compute shorter-term inflation expectations, although the assumptions of PPP, UIP and CIP may be less likely to hold over shorter horizons, and we therefore do not present them in this paper.

We derive these long-term inflation expectations for eight economies where no market for inflation swaps exists, namely, Canada, China, the Czech Republic, Hong Kong, Norway, Singapore, Sweden and Switzerland.[2] We assess the plausibility of the PPP-UIP and PPP-UIP-CIP measures by applying the method to four economies with inflation swap markets, namely, the euro area, Japan, the United Kingdom and the United States. For these four economies, we then compare the PPP-UIP and PPP-UIP-CIP measures with the actual swap market data on inflation expectations. For all economies in our sample, we compare the PPP-UIP and PPP-UIP-CIP measures with the survey data from Consensus Economics and, where available, with expectations computed from inflation-linked bonds.

Our aim is to provide a tool that assesses whether financial market prices point to changes in long-term inflation expectations. There are a number of caveats to our approach, relating in particular to the potential presence of liquidity and risk premia, which can influence both the level and the volatility of

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[2] Three of these countries also do not have inflation-linked government bonds: Norway, Singapore and Switzerland. Other countries do have inflation-linked government bonds, but they are often available only for a limited maturity spectrum; moreover, liquidity is often low at long maturities.

our derived measures. The appropriate way to make use of our measures of inflation expectations is to concentrate on low-frequency movements rather than on the absolute level or high-frequency movements.

We also discuss how our derived long-term inflation expectations might be used in economic analysis. For each country, we aggregate our derived measures by averaging them and present evidence on the information content of expectations for current inflation, assess whether long-term expectations respond to current inflation and output growth or economic news, and compute the implied long-term real interest rate for the different economies in our sample.

The remainder of the paper is structured as follows. Section 2 reviews the literature. Section 3 discusses how we compute inflation expectations by assuming PPP-UIP and PPP-UIP-CIP. Section 4 presents the raw data and Section 5 presents the derived long-term inflation expectations. Section 6 discusses how these measures might be used in economic analysis. Finally, Section 7 concludes the paper.

2. Literature review

The literature on long-term inflation expectations typically focuses on the question of whether expectations are well anchored. The comparison is often made across countries with different monetary policy regimes (see Castelnuovo et al., 2003, Demertzis et al., 2010, and Van der Cruijsen and Demertzis, 2007), with a particular focus on the question of whether inflation targets help anchor expectations more firmly. Another comparison made in the literature is over time. One question of recent interest is whether inflation expectations have become less well anchored since the global financial crisis (see Galati et al., 2011, and Gerlach-Kristen et al., 2011).

The literature on inflation expectations can be grouped by measures used. For instance, Capistrán and Ramos-Francia (2010), Castelnuovo et al. (2003), Demertzis et al (2010) and Van der Cruijsen and Demertzis (2007) use inflation expectations for different sets of countries provided by Consensus Economics. Gerlach-Kristen et al. (2011) and Hofmann and Zhu (2013) use inflation swap data and Consensus Economics data, and Galati et al. (2009) and Haubrich et al. (2012) use surveys of professional forecasters and nominal and inflation-linked bond yields, with Galati et al. (2011) using inflation swaps. These papers also discuss the advantages and disadvantages of the different measures of inflation expectations.[3] Krishnamurthy and Vissing-Jorgensen (2011) use inflation swaps and nominal and inflation-linked bond yields, and Moessner (2015) and Rodriguez and Yoldas (2016) use inflation swaps only.

The papers using market expectations concentrate on countries where either inflation swap or inflation-linked government bond markets exist. Hurd and Relleen (2006) compare inflation swaps and expectations from inflation-linked bonds for the euro area, the United Kingdom and the United States. Fleming and Sporn (2013) use transactions data to study the US inflation swap market. Inflation expectations implied by inflation swaps and differences between nominal and real government bond yields should be equal in the absence of market frictions. In practice, they often differ, as discussed in Fleming and Sporn (2013). For the United States, Fleckenstein, Longstaff, and Lustig (forthcoming)

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[3] See also Adrian and Wu (2009) for a discussion of problems with inflation expectations derived from bond yields.

suggest that the difference is due to a mispricing of inflation-linked government bonds relative to nominal government bonds, and not due to problems with inflation swaps. Christensen and Gillan (2011) suggest that the difference in the United States is due to a liquidity premium in inflation swaps and in inflation-linked government bonds, with the liquidity premium in inflation swaps being due to reduced funding costs for buyers of inflation and hedging costs for sellers of inflation. Lucca and Schaumburg (2011) also suggest that the difference in the case of the United States is due to such hedging costs using inflation swaps due to liquidity premia in inflation-linked government bonds.

Mandel and Barnes (2013) argue that depending on the depth of domestic markets, inflation expectations as implied by domestic inflation swaps or nominal and inflation-linked government bonds may not be reliable. They propose an alternative way to obtain market-based inflation expectations that follows a procedure outlined in a report by Goldman Sachs Economics Research (2013). This procedure combines market inflation expectations from one country with a liquid market with the spot and forward exchange rate of the currency pair to obtain inflation expectations for the other country. Kamada and Nakajima (2014) follow this approach and calculate Japanese 5-year inflation expectations via several countries. Krugman (2013) follows a second, however similar approach, combining inflation expectations from one country with the expected interest differential between the two countries, with the latter captured by interest rate swaps. Section 3 below reviews these two approaches and discusses how we adjust them to obtain market-based long-term inflation expectations.

Since we use two different approaches and several currency pairs, we obtain for each country several measures of market-based inflation expectations. We then aggregate these measures by country by averaging. This has the advantage that it can produce more precise measures than the individual measures, as shown in the forecasting literature. Elliott (2011) discusses reasons why in practice simple averages of forecasts have often been used instead of an optimal combination of forecasts as a weighted average based on the relative variances and covariances of the forecasts that minimised the mean square error of the combined forecast (see Bates and Granger, 1969). A literature survey by Clemen (1989) concludes that in many cases averaging forecasts seems to be a more robust procedure in practice than optimal forecast combination. Stock and Watson (2001) study 49 methods for constructing forecasts of a large number of US macro series. They find that combining the methods is better than using individual methods and that averaging the methods and taking the median of the forecasts performs best. Reasons why forecast averaging could work better in practice than an optimal combination of forecasts include estimation error and the effects that variations in the data generating process over time have on this estimation error. Elliott (2011) studies under which conditions forecast averaging and optimal combination are equivalent.

In Section 6 we discuss what questions can be addressed with our derived measures of inflation expectations. A preliminary issue is whether long-term inflation expectations impact the current level of inflation. There is a large amount of literature on the forward-looking Philips curve (see e.g., Clarida et al., 1999, Fuhrer and Moore, 1995, Gali and Gertler, 1999, Christiano et al., 2005). Mavroeidis et al. (2014) provide an overview on the empirical evidence of inflation expectations in the New Keynesian Philips curve.

Another important issue that can be addressed with inflation expectations is central bank credibility. Despite its importance for policymakers, the question whether inflation expectations are well anchored has remained open (Mavroeidis et al., 2014); answering this question is hard because of the difficulties

in measuring inflation expectations. A number of recent papers have studied the anchoring of inflation expectations by looking at their reactions to macroeconomic news (Autrup and Grothe, 2014, Bauer, 2015, Beechey et al., 2011, Ehrmann, 2015, Ehrmann et al., 2011, Nautz et al., 2017, and Nautz and Strohsal, 2015).

Finally, we also discuss what our derived measures of inflation expectations imply for long-term, or equilibrium, real interest rates. Recent years have seen a lively debate on the equilibrium real interest rate: Has it declined, if so how much, and why? Recent references include Chetwin and Wood (2013), Hamilton et al. (2015), Hördahl et al (2016), King and Low (2014), Laubach and Williams (2015), Rachel and Smith (2015), Reifschneider et al (2015), Rogoff (2015) and Zhu (2016). The level of the equilibrium real interest rate determines together with the inflation objective the equilibrium nominal interest rate. The higher this rate, the less often the central bank faces the effective lower bound.

3. Method

In this section, we discuss two approaches to obtaining long-term market-based inflation expectations by combining foreign and domestic financial market data. To relate the two approaches to the underlying theory, we refer to them as PPP-UIP and PPP-UIP-CIP approaches, respectively. We also discuss the caveats of these approaches.

3.1 The PPP-UIP approach

Krugman (2013) computes market-based inflation expectations for Japan based on purchasing power parity (PPP) and uncovered interest rate parity (UIP). PPP states that

$$S_t = \frac{P_t}{P_t^*}, \tag{1}$$

where S_t denotes the nominal exchange rate at time t, P_t the domestic and P_t^* the foreign price level at time t. Taking logs, expectations at time t, E_t, and differencing yields

$$E_t(e_{t+1}) - e_t = E_t(\pi_{t+1}) - E_t(\pi_{t+1}^*), \tag{2}$$

where $E_t(\pi_{t+1})$ denotes expected domestic inflation at time $t + 1$, $E_t(\pi_{t+1}^*)$ expected foreign inflation at time $t + 1$, and $e_t = \log(S_t)$. Then, assume that UIP holds, i.e.

$$E_t(e_{t+1}) - e_t = i_t - i_t^*, \tag{3}$$

with $i_t - i_t^*$ being the interest rate differential between the home and foreign country. Using this in equation (2) gives

$$E_t(\pi_{t+1}) = E_t(\pi_{t+1}^*) + i_t - i_t^*. \tag{4}$$

This is the PPP-UIP-based one-period ahead measure of inflation expectations, but this method can be used to compute expectations over the next j years. Krugman computes 10-year inflation expectations

for 2013 for Japan using 10-year interest rate swaps and the 10-year breakeven inflation rate constructed from US TIPS.[4] Section 3.3 shows how to derive long-term expectations that abstract from inflation in the short run. Specifically, we concentrate on 5y/5y expectations.

3.2 The PPP-UIP-CIP approach

Mandel and Barnes (2013), following Goldman Sachs Economics Research (2013), compute market-based inflation expectations for Japan based on PPP, UIP and covered interest rate parity (CIP). CIP states that

$$f_t - e_t = i_t - i_t^*, \tag{5}$$

where f_t is the log of the forward exchange rate. Together with UIP (equation (3)) this gives

$$E_t(e_{t+1}) = f_t, \tag{6}$$

which is also referred to as the unbiasedness hypothesis. Replacing $E_t(e_{t+1})$ with the forward exchange rate f_t according to equation (6) in equation (2) gives

$$E_t(\pi_{t+1}) = E_t(\pi_{t+1}^*) + f_t - e_t. \tag{7}$$

This is the PPP-UIP-CIP-based one-period ahead measure of inflation expectations. Mandel and Barnes present implied inflation expectations for Japan for horizons of 5, 7 and 10 years.

3.3 Computing 5y/5y inflation expectations

We take these computations one step further and infer the 5y/5y forward inflation expectations, i.e., the measure that is commonly used to assess long-run expectations and monetary policy credibility. In line with equation (4) and denoting expected inflation over a horizon of j years by Π_t^j, the PPP-UIP measure of inflation expectations is given by

$$\Pi_t^j = \Pi_t^{*j} + i_t^j - i_t^{*j}, \tag{8}$$

where i_t^j is the interest rate swap rate for a maturity of j years. Inflation and interest rates refer to annual rates.

Similarly, in line with equation (7), the PPP-UIP-CIP measure of inflation expectations over a horizon of j years is given by

$$\Pi_t^j = \Pi_t^{*j} + f_t^j - e_t. \tag{9}$$

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[4] Krugman criticises the assumption that the real exchange rate in equation (1) equals unity. He argues that at the time of his writing, the yen was undervalued and therefore corrects equation (4) by the expected real appreciation. Taking expected real exchange rate changes into account would be a possible extension of the method presented in the present paper. However, as we focus on 5y/5y expectations, PPP is more likely to hold, and with it, the assumption made in equation (1).

Here, $f_t^j = \log F_t^j$, which we calculate from the j-year forward exchange rate quoted on Bloomberg, F_t^{Bj}, as follows. The data on forward exchange rates from Bloomberg are either j= 5 or 10 years ahead. We compute the annualised compound rate for each of these maturities as a proxy for the average yearly expected change in the exchange rate according to $1 + \frac{F_t^j - S_t}{S_t} = \left[1 + \frac{F_t^{Bj} - S_t}{S_t}\right]^{\frac{1}{j}}$. Rewriting $f_t^j - e_t =$ $\log\left[1 + \frac{F_t^j - S_t}{S_t}\right]$ and approximating $\log(1 + x_t) \approx x_t$ for $x_t = \frac{F_t^j - S_t}{S_t}$, gives $f_t^j - e_t = \left[1 + \frac{F_t^{Bj} - S_t}{S_t}\right]^{\frac{1}{j}} - 1$, which we use in equation (9).

We compute domestic inflation expectations for both the 5- and 10-year maturities. From these, we then calculate 5y/5y forward inflation expectations, $\pi_t^{5/5}$, using the standard formula

$$\pi_t^{5/5} = \frac{(1 + \Pi_t^{10})^2}{(1 + \Pi_t^5)} - 1, \tag{10}$$

where Π_t^5 and Π_t^{10} are the 5- and 10-year inflation expectations.

3.4 Caveats

Our analysis assumes that PPP, UIP and CIP hold. There are caveats to each of these parity assumptions. First, PPP assumes that the nominal exchange rate correctly reflects the respective price levels in two countries, i.e., that there is no undervaluation or overvaluation. However, empirical evidence suggests that in the short run deviations from PPP can be substantial. Nevertheless, in the long run it seems to be a valid assumption (for an overview of the literature see e.g., Sarno and Taylor, 2002, Taylor and Taylor, 2004 and Taylor, 2006, also Abuaf and Jorion, 1990). In this paper, we compute 5y/5y expectations, which means that the short-run expectations drop out. In that sense, the 5y/5y expectations reflect a true long-term perspective, where PPP seems to hold best.

Second, the assumption that interest rate differentials reflect expected exchange rate movements and nothing else, as under UIP, may not be met all the time. Interest rate swaps contain liquidity and risk premia. These may have increased over recent years due to global banks' reduced appetite for market-making and arbitrage (Arai et al., 2016).[5] However, similar to PPP, the assumption of UIP is less critical in the long-run (see e.g., Chinn and Quayyum, 2012 and Chinn and Meredith, 2004 and 2005).

Third, CIP may be too strong an assumption. In recent years, CIP has performed poorly in currency pairs. Including with the USD in particular. Several possible explanations for the widening of USD cross-currency basis swap spreads, one measure of violations of CIP, have been suggested: increased demand for U.S. dollars due to a divergence in monetary policy between the United States and other advanced countries; global banks' reduced appetite for market-making and arbitrage due to regulatory reforms; and a decrease in the supply of U.S. dollars from foreign reserve managers and sovereign wealth funds against the background of declines in commodity prices and emerging currency depreciations.[6] We

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[5] Liquidity premia are also contained in inflation swap rates, which implies that not all movements in domestic market-based inflation expectations are necessarily due to changed inflation expectations.
[6] See Arai et al. (2016), Avdjiev et al. (2016), Baba and Packer (2009), Du et al. (2016), Iida et al. (2016), Sushko et al. (2016) and Wong et al. (2016).

address this issue by deriving our measures of 5y/5y forward inflation expectations also through cross-currency pairs not including USD (where available), and in addition via the PPP-UIP approach only.

Naturally, addressing these caveats in detail for each country would be desirable, but this goes beyond the scope of this paper. Our aim is to provide a tool for deriving long-term market-based inflation expectations, which we feel are a useful addition to survey-based data. Our focus is not on testing whether all the assumptions are always and fully met for all countries over the whole sample period.

4. Data

Our sample period is 1 June 2004 to 24 January 2017, and our data sources are Bloomberg, Consensus Economics, the IMF International Financial Statistics database, Datastream and national data.

From Bloomberg, we use inflation swaps with maturities of 5 and 10 years for those countries where these data are available. US inflation swaps are based on the US CPI urban consumers index, Euro area inflation swaps are based on Euro area HICP inflation, UK inflation swaps are based on the UK RPI index (including tobacco), and Japanese inflation swaps are based on the Japanese CPI index for government CPI bonds, an index specifically created for Japanese CPI-linked bonds.

For all countries in our sample, we obtain from Bloomberg interest rate swaps with maturities of 5 and 10 years. We choose interest rate swaps as long-term nominal interest rates, since as swaps, their credit risk most closely matches that of the inflation swaps.[7] Figure 1 shows the 5-year and 10-year interest rate swaps for each country. Interest rate swap data are available for all countries in our sample, forward exchange rates are not available for all countries at both these maturities. Figure 2 shows the 5-year and 10-year forward exchange rates against the USD for those countries where the data are available. These data and the forward exchange rates against the EUR and the GBP are also from Bloomberg, as are the spot exchange rates.

Table 1 summarises the data availability. For the first group of countries in Table 1, which comprises the Euro area, Japan, the United Kingdom and the United States, we have full data availability, i.e., a domestic inflation swap market and forward exchange rates. In what follows, we use only the Euro area, UK and US inflation swaps to derive inflation expectations in other countries, but not the less liquid Japanese inflation swaps. According to Hurd and Relleen (2006), the Euro area inflation swaps market was more active in 2006 than that in the United Kingdom and the United States, with an initial driver of this market having been Italian demand for products by investors to hedge against high inflation. The UK and US inflation swap markets had seen increased activity from 2005 (Hurd and Relleen, 2006).[8] The Japanese inflation swaps market only became more active later, with Japanese inflation swaps rates available on Bloomberg only since March 2007.

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[7] An alternative measure of long-term interest rates are government bond yields. Compared with interest rate swaps, government bonds carry less credit risk, but they can be affected by a flight to safety, so that one would need to correct for the differences in credit risk premia.

[8] Fleming and Sporn (2013) found that the US inflation swap market grew rapidly between 2006 and 2012, that the US inflation swaps market was reasonably liquid and transparent, despite its over-the-counter nature and low level of trading activity, that transaction prices were typically near widely available end-of-day quoted prices and that realised bid-ask spreads were modest.

For the Euro area, for example, we compute PPP-UIP-based inflation expectations via (i) UK inflation swaps and UK and Euro area interest rate swaps, and via (ii) US inflation swaps and US and euro area interest rate swaps. In addition, we compute PPP-UIP-CIP-based inflation expectations via (iii) UK inflation swaps and GBP/EUR forward exchange rates, and via (iv) US inflation swaps and USD/EUR forward exchange rates. For Japan, the UK and the US, we proceed in analogous fashion. This yields four different measures of 5y/5y forward inflation expectations per economy.

Table 1: Data availability

	Interest rate swaps[a]	Forward exchange rates against USD[a]	Forward exchange rates against EUR[a]	Forward exchange rates against GBP[a]	Domestic inflation swap market	Consensus Economics
Countries with domestic inflation swap market and forward exchange rates						
Euro area	Yes	Yes		Yes	Yes	Yes
Japan	Yes	Yes	No	No	Yes	Yes
United Kingdom	Yes	Yes	Yes		Yes	Yes
United States	Yes		Yes	Yes	Yes	Yes
Countries without domestic inflation swap market but with forward exchange rates						
Canada	Yes	Yes	No	No	No	Yes
Norway	Yes	Yes	No	No	No	Yes
Sweden	Yes	Yes	No	No	No	Yes
Switzerland	Yes	Yes	Yes	No	No	Yes
Countries with neither domestic inflation swap market nor forward exchange rates[a]						
China	Yes	No	No	No	No	Yes
Czech Republic	Yes	No	No	No	No	Yes
Hong Kong	Yes	No	No	No	No	Yes
Singapore	Yes	No	No	No	No	Yes

Notes: [a] At maturities of both 5 and 10 years.

The second group of countries in Table 1 has no domestic inflation swap market. The group consists of Canada, Norway, Sweden and Switzerland. We compute inflation expectations again with the above described two approaches. For the PPP-UIP measure, we use euro area/UK/US inflation and interest rate swaps together with the respective country's interest rate swaps. For the PPP-UIP-CIP measure, we use US inflation swaps together with the respective country's forward exchange rates against the USD. For Switzerland, the only country in this group where the 10-year EUR forward exchange rate is available, we use in addition the euro area inflation swaps and EUR/CHF forward exchange rates. This yields four (except for Switzerland five) different measures of 5y/5y forward inflation expectations for each country.

The third group comprises China, the Czech Republic, Hong Kong and Singapore. For these countries, there is no domestic inflation swap market nor are there forward exchange rates available at both maturities of 5 and 10 years. We therefore only compute PPP-UIP inflation expectations, using euro area/UK/US inflation and interest rate swaps together with the respective country's interest rate swaps, but no PPP-UIP-CIP expectations. Per country, this yields three PPP-UIP measures of 5y/5y inflation expectations.

Our derived measures of long-term inflation expectations are presented below together with domestic inflation swap data, where available, survey data from Consensus Economics, and for the Euro area, the United Kingdom and the United States expectations computed from inflation-linked bonds.[9] The Consensus data measure the expected rate of consumer price inflation 6 to 10 years in the future. This horizon corresponds to 5y/5y forward inflation expectations starting at the end of the 5th year. We also use 5y/5y forward breakeven inflation rates derived from nominal and inflation-linked government bonds for the euro area, the United Kingdom and the United States. For the United States, these are computed following the methodology of Gürkaynak et al. (2008), for the United Kingdom, they are calculated by the Bank of England and for the euro area, they are computed as simple averages for France and Germany (weekly averages based on linearly interpolated business daily figures, with the weekly numbers assigned to each day of the week).[10]

In Section 6, we discuss three issues of interest for which our measures of inflation expectations can be used. In this analysis, we make use of inflation rates from Datastream and national data and the growth rate of real GDP from the IMF International Financial Statistics. We also use Citigroup economic surprise indices from Bloomberg.

5. Derived long-term market inflation expectations

In this section, we present our measures for 5y/5y forward market-based inflation expectations. Since we obtain between three to five measures per country, we present the range of the available measures together with the median and the mean. The range of measures can be thought of as a measure of uncertainty regarding future inflation. We also include the long-term expectations from Consensus Economics and, for the first group of countries in Table 1, expectations from the domestic inflation swap market.

Figures 3 to 6 present inflation expectations for the three groups of countries discussed in Table 1. Before turning to the specific outcomes, two points are worth noting. First, the absolute level of the derived measures of inflation expectations may be influenced by the differences in levels of the domestic and foreign liquidity and risk premia. The focus in the interpretation should therefore lie on movements in expectations, rather than absolute levels. Second, the derived measures are rather volatile, while 5y5y expectations should per se be rather stable if inflation is well anchored. The volatility is due to the volatile underlying data series used in the construction and hence again to liquidity and risk premia. In using the derived measures as an early indicator of de-anchoring, the focus should be laid on the low-frequency movements.

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[9] We use inflation expectations computed from index-linked government bonds only for comparison because inflation-protected bonds are often available only for a limited maturity spectrum; moreover, liquidity is often low at long maturities. In many countries there is no inflation-linked government bond market at all (e.g. Norway, Singapore and Switzerland).

[10] See the Federal Reserve website at http://www.federalreserve.gov/pubs/feds/2008/200805/200805abs.html for the US. For the UK, see http://www.bankofengland.co.uk/statistics/Pages/yieldcurve/archive.aspx. We only have data available until June 2015 from a file downloaded in 2015, since publication of the breakeven inflation rates on this website is currently temporarily suspended while the estimation methodology is reviewed.

5.1 Countries with domestic inflation swap markets and forward exchange rates

Figure 3 shows the estimates for the euro area, Japan, the United Kingdom and the United States. The blue band spans the minimum to maximum of the derived measures of inflation expectations. The blue and red lines are their median and mean, respectively. The dashed green line is long-run inflation expectations from Consensus Economics and the black line is the 5y/5y expectations constructed from the domestic inflation swap market. To make the movements comparable, we limit the axis range to 5 percentage points for all economies. In Figure 4, we also show 5y/5y forward breakeven inflation rates derived from nominal and inflation-linked government bonds for the euro area (using government bonds from France and Germany), the United Kingdom and the United States.

Generally, the different series move together, though the survey data tend to be more stable than the series based on market data. For all four economies, the blue band reflecting the range of our derived measures widens over time, suggesting an increase in uncertainty regarding future inflation. This may be due to the global financial crisis and the uncertainties pertaining to the effectiveness of unconventional monetary policy measures. The widening is most pronounced in the euro area and Japan.

Turning to the individual countries, we find for the euro area that the 5y/5y inflation expectation derived from the domestic inflation swap market (the black line) follows a similar path as the PPP-UIP and PPP-UIP-CIP measures. The domestic measure was more stable in 2009, when our derived measures increased sharply. This could have been partly due to increased liquidity and risk premia during the global financial crisis, as well as violations of CIP, as reflected in widening cross-currency basis swap spreads. During the euro area sovereign debt crisis, our derived measure increased more than the domestic measure, but less so than during the global financial crisis. Similar to the global financial crisis, the divergence could have been partly due to increased liquidity and risk premia during the euro area sovereign debt crisis and to violations of CIP (Moessner and Allen, 2013). At the end of our sample, all measures of long-run inflation expectations are close to 2%.

For Japan, the domestic and the derived market expectations move closely together. The market expectations regarding long-run inflation are lower than those reported by Consensus Economics, which lie closer to the Bank of Japan's price stability target of 2%. At the end of the sample, the survey data lie within the widened blue band spanned by our derived market expectations.

For the United Kingdom, the domestic measure of inflation expectations tends to be higher than our derived measures. The difference has increased over time. Expectations as captured by Consensus Economics are closer to our derived measures than to the domestic inflation swap market expectations. At the end of the sample, the domestic measure implies an expected long-run inflation rate of 3.5%, whereas our derived measures lie at 2% and thus at the Bank of England's inflation target for consumer price inflation (CPI). The fact that the domestic market measure of inflation expectations is higher is at least partly because UK inflation swaps are based on the retail price index (RPI), rather than the CPI index. RPI inflation in the UK has generally tended to be higher than CPI inflation. It is not clear which measure of inflation market participants have implicitly in mind when trading interest rate swaps. This gives rise to a certain ambiguity regarding which measure of inflation our PPP-UIP and PPP-UIP-CIP-based estimates actually capture.

For the United States, our derived measures of inflation expectations tend to be higher than both the domestic market data and the survey expectations. The difference is most clearly visible from 2014 onwards. At the end of the sample, the derived measures lie between 3 and 5%, while inflation expectations from the domestic inflation swap market and Consensus Economics are slightly above 2% and thus much closer to the 2% at which the Federal Reserve aims. These results also suggest that for a country such as the United States with a relatively liquid domestic inflation swaps market, it is not advantageous to derive inflation expectations from less liquid foreign inflation swaps markets via PPP, UIP (and CIP). By contrast, for a country such as Japan with a less liquid domestic inflation swaps market, it may be advantageous to derive inflation expectations from more liquid foreign inflation swaps markets.

Overall, Figures 3 and 4 suggests two things: First, Consensus Economics expectations tend to be close to the level of inflation the central bank targets. Market-based measures display more variability. Second, the measure of inflation expectations we derive generally resemble the inflation expectations reflected in domestic inflation swap rates.

Table 2 presents some summary statistics to compare the mean of our derived measures of inflation expectations with other available 5y/5y measures of inflation expectations. We present the average difference in level compared with Consensus Economics expectations, domestic inflation swaps and the domestic breakeven rate derived from inflation-indexed bonds. We also compare the average difference in level of the domestic measures with each other and with Consensus Economics expectations. In addition, we show how the different measures correlate by presenting the correlations of monthly changes. As already observed in Figures 3 and 4, we can also see from Table 2 that our derived measure of inflation expectations is plausibly close to other available measures. These findings support the notion that PPP, UIP and CIP can be used to compute reasonable long-run market inflation expectations for countries that do not have a domestic inflation swap market, which we will perform in the next section.

Table 2: Differences and correlations for different measures of 5y/5y forward inflation expectations

	Euro area	Japan	United Kingdom	United States
Differences[1]				
Derived measure minus Consensus	0.42	-0.69	0.46	1.11
Derived measure minus domestic inflation swaps	0.12	0.29	-0.66	0.60
Derived measure minus domestic breakeven inflation rate	0.23		-0.54	0.87
Domestic inflation swaps minus Consensus	0.31	-0.97	1.12	0.50
Domestic inflation swaps minus breakeven inflation rate	0.12		0.12	0.26
Breakeven inflation rate minus Consensus	0.19		1.00	0.24
Correlations of monthly changes[2]				
Derived measure and domestic inflation swaps	0.29	-0.11	-0.19	0.20
Derived measure and domestic breakeven inflation rate	0.18		0.05	0.56
Domestic inflation swaps and breakeven inflation rate	0.41		0.58	0.30

Notes: [1] Differences in percentage points for each economy using daily data, for subperiods for each economy between 1 June 2004 and 24 January 2017 where all four measures are available, as shown in Figure 4. [2] Correlations of monthly changes, for subperiods for each economy between June 2004 and December 2016 where all three measures are available, as shown in Figure 4.

5.2 Countries without domestic inflation swap markets but with forward exchange rates

Figure 5 presents measures of long-run market inflation expectations for countries without a domestic inflation swap market but with forward exchange rates, i.e., Canada, Norway, Sweden and Switzerland. We again use the PPP-UIP and the PPP-UIP-CIP approaches. For the first group of countries, there has been an increase in uncertainty over time, as captured by the width of the blue band. Uncertainty seems highest for Switzerland. For Canada, Norway and Sweden, market expectations tend to be higher than the survey data, though they approach each other at the end of the sample. For Switzerland, market and survey expectations tend to lie closer together, with market expectations slightly below survey expectations on average over the sample.

For Canada, where the central bank targets 2% inflation, market expectations are on the high side at the end of the sample, ranging between 2 and 4%. Consensus Economics expectations are stable at 2% throughout the sample. This pattern is the same as for the first group of countries, where we found that market-based expectations, be it those from domestic inflation swap markets or our derived measures, displayed more variability than Consensus data. Since in that group of countries, both types of market-based expectations moved together, this suggests that our derived measures may be treated as a proxy for the non-existent domestic inflation swap market in Canada and the other countries in our sample.

For Norway, inflation expectations at the end of the sample range between 2 and 4%; the Bank of Norway's inflation target is 2.5%. Again, the market-based measure is more volatile than the Consensus expectations. The latter lie in the region of 2.5% and thus again are very close to the inflation target of

the central bank. The Riksbank aims for 2% inflation. Consensus expectations are at this level, whereas our derived measures tend to be somewhat higher, lying between approximately 2 and 4%. The Swiss National Bank equates price stability with an inflation rate between 0 and 2%. At the end of the sample, market expectations range between around 0 and 2.5%.

5.3 Countries with neither domestic inflation swap market nor forward exchange rates

Figure 6 presents the data for China, the Czech Republic, Hong Kong and Singapore. For these countries, only the PPP-UIP approach can be used to compute market expectations, since there are no forward exchange rates at maturities of both 5 and 10 years that would be necessary for the PPP-UIP-CIP approach.

For China and, to a lesser extent, Singapore, market inflation expectations have increased in the past few years and clearly exceed the survey expectations at the end of the sample. At the end of the sample, market expectations for China lie between 5 and 7%, and survey expectations between 2 and 3%. For Singapore, market expectations fall in a band of 3 to 5% at the end of the sample; Consensus expectations are slightly below 2%. Neither China nor Singapore have an explicit inflation target.

For the Czech Republic and Hong Kong, market expectations and survey data move closely together. At the end of the sample, market expectations lie between 1 and 3% for the Czech Republic; the central bank's inflation target is 2%. For Hong Kong, which has a currency board, our derived long-term inflation expectations at the beginning of 2017 were between 3 and 5%.

It is noteworthy that in Figure 6 there is again a widening of the blue bands over time, but that this widening is less pronounced than in Figures 3 and 5. This might be because we compute fewer measures of inflation expectations due to the missing forward exchange rates.

6. What to do with these data

This section describes to which analyses our measures of inflation expectations lend themselves. The applications we discuss make use of the mean of the derived long-term inflation expectations. However, the results are generally robust to exchanging the mean with the median of these expectations. Using the average removes some of the volatility of the individual measures, but as discussed at the beginning of Section 5, the potential presence of liquidity and risk premia may render these measures overly volatile and may also affect their level. One way to address these issues would be to concentrate on low-frequency changes, but we abstain from this given that the purpose of this section is only to illustrate potential applications.

6.1 Information content of expectations

A first question to address is whether long-term inflation expectations impact on the current level of inflation. What we present here is a rough check whether the long-term expectations computed above

might be useful in this type of analysis. Table 3 presents the estimation output for the Philips curve regression

$$\pi_t = c_0 + c_1\pi_{t-1} + c_2\pi_t^{5/5} + c_3\Delta y_t + \epsilon_t, \tag{11}$$

where we use monthly averages for $\pi_t^{5/5}$ and where Δy_t denotes the annual growth rate of real GDP. Since new data become available only quarterly (annually for the case of China), this series follows a step function.

Table 3 reports the estimation output. It can be seen that long-term inflation expectations are mostly insignificant. For the Euro area and the United Kingdom, however, they are significant with a positive sign. This could be seen as evidence that higher future inflation expectations tend to increase inflation already today. However, this significance disappears if we estimate equation (11) with inflation expectations lagged one month and output growth lagged one quarter, to account for potential endogeneity and report lags, i.e.

$$\pi_t = c_0 + c_1\pi_{t-1} + c_2\pi_{t-1}^{5/5} + c_3\Delta y_{t-3} + \epsilon_t. \tag{12}$$

The corresponding estimates are reported in parentheses in Table 3.

Table 3: Information content of the derived measure of long-term inflation expectations

	Lagged inflation	Long-term inflation expectations	Real output growth	Adjusted R^2
Canada	0.768*** (0.807***)	-0.136 (-0.070)	0.083*** (0.049**)	0.778 (0.764)
China	0.970*** (0.967***)	0.130 (0.146)	0.015 (0.017)	0.924 (0.924)
Czech Republic	0.940*** (0.942***)	0.146 (0.066)	0.034*** (0.027*)	0.935 (0.931)
Euro area	0.928*** (0.951***)	0.131** (0.023)	0.066*** (0.029*)	0.953 (0.947)
Hong Kong	0.858*** (0.851***)	0.078 (-0.010)	0.025 (0.032)	0.738 (0.732)
Japan	0.958*** (0.944***)	-0.083 (-0.053)	0.030*** (0.031***)	0.910 (0.912)
Norway	0.884*** (0.887***)	-0.095 (-0.045)	-0.002 (-0.014)	0.788 (0.795)
Singapore	0.988*** (0.956***)	-0.047 (-0.070)	0.050*** (0.046***)	0.925 (0.928)
Sweden	0.950*** (0.824***)	0.160 (0.188*)	0.054*** (0.040***)	0.933 (0.925)
Switzerland	0.893*** (0.940***)	0.088 (-0.006)	0.068*** (0.017)	0.923 (0.915)
United Kingdom	0.958*** (0.955***)	0.183* (0.158)	0.014 (0.015)	0.941 (0.942)
United States	0.916*** (0.928***)	0.124 (-0.001)	0.062 (0.018)	0.888 (0.881)

Note: OLS regressions for equations (11) and (12) using monthly data, June 2004 to December 2016. Estimates for equation (12) in parentheses. */**/*** indicates significance at the 10/5/1 percent level. Constant included but not reported here.

Overall, Table 3 suggests that long-term inflation expectations generally do not affect actual inflation. However, shorter-term expectations might, and for countries without their own inflation swap markets, the PPP-UIP and PPP-UIP-CIP approaches presented above could be applied to compute such shorter-term market expectations as well. However, the assumptions of PPP and UIP may be less likely to hold over shorter horizons, and we do not consider short-term expectations in this paper.

6.2 Are inflation expectations well-anchored?

The second question for which long-term inflation expectations have been used in the literature is to assess the credibility of central banks' inflation objectives.[11] The literature typically examines whether long-term inflation expectations are well-anchored or respond to economic news, which they should not under a credible inflation target. With our approach, this question can also be addressed for countries without domestic inflation expectations markets. Generally, the literature has found that inflation expectations are well anchored in countries with inflation targets.

To get a sense of whether there is a response of long-term inflation expectations to macroeconomic data, we estimate the regression

$$\pi_t^{5/5} = c_0 + c_1 \pi_{t-1}^{5/5} + c_2 \pi_t + c_3 \Delta y_t + \epsilon_t \tag{13}$$

using monthly data. We thus examine whether expectations respond to inflation and output growth. For a credible central bank, only the constant should be significant.

Table 4 presents the estimation output. There is some evidence that expectations increase when current inflation rises and when output growth is low. We estimate significant coefficients for the Czech Republic, the euro area, Sweden and the United Kingdom. Of the coefficients identified as significant, about half remain significant if we estimate equation (13) with inflation lagged one month and output growth lagged one quarter, to account for potential endogeneity and report lags, i.e.,

$$\pi_t^{5/5} = c_0 + c_1 \pi_{t-1}^{5/5} + c_2 \pi_{t-1} + c_3 \Delta y_{t-3} + \epsilon_t \ . \tag{14}$$

Table 4 reports these estimates in parentheses. Thus, there is some evidence that credibility is less than perfect. This finding may in part be due to the global financial crisis, which impacted both current economic variables and expectations about the future.

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[11] This literature has focused on those countries for which inflation-linked bond data are available (e.g. Sweden, the United Kingdom and the United States in Gürkaynak, Levin and Swanson, 2010).

Table 4: Drivers of long-term inflation expectations

	Lagged expectations	Inflation	Real output growth	Adjusted R^2
Canada	0.900*** (0.886***)	-0.001 (0.001)	-0.003 (-0.005)	0.840 (0.835)
China	0.878*** (0.874***)	-0.016 (-0.018)	0.000 (0.001)	0.813 (0.813)
Czech Republic	0.909*** (0.923***)	0.020*** (0.017**)	-0.006* (-0.001)	0.946 (0.944)
Euro area	0.964*** (0.987***)	0.028*** (0.018)	0.000 (0.011)	0.958 (0.959)
Hong Kong	0.884*** (0.906***)	-0.002 (-0.008)	-0.001 (-0.006)	0.784 (0.785)
Japan	0.912*** (0.914***)	0.005 (0.007)	-0.005 (-0.002)	0.839 (0.834)
Norway	0.953*** (0.969***)	-0.018 (0.010)	-0.006 (0.002)	0.925 (0.924)
Singapore	0.985*** (0.991***)	0.008 (0.006)	-0.001 (-0.001)	0.947 (0.950)
Sweden	0.864*** (0.863***)	0.008 (0.018**)	-0.009** (-0.009**)	0.864 (0.866)
Switzerland	0.968*** (0.975***)	0.015 (0.010)	-0.000 (0.008)	0.943 (0.942)
United Kingdom	0.863*** (0.902***)	0.021** (0.022**)	-0.007* (-0.005)	0.851 (0.876)
United States	0.886*** (0.896***)	0.000 (-0.007)	-0.001 (-0.009)	0.781 (0.782)

Note: OLS regressions for equations (13) and (14) using monthly data, July 2004 to December 2016. Estimates for equation (14) in parentheses. */**/*** indicates significance at the 10/5/1 percent level.

Next, to study the question of whether long-term inflation expectations have been well-anchored, we study their response to economic news at the monthly and weekly frequencies. We consider long-term inflation expectations to be well-anchored if they do not respond to economic news. To measure economic data surprises, we use information on the surprise components of macroeconomic data releases in the form of the Citigroup economic surprise indices at a daily frequency, and averaged over one month (or one week). Citigroup economic surprise indices measure economic surprises relative to market expectations (actual releases minus Bloomberg median survey expectations); they are calculated daily in a rolling three-month window and are defined as a weighted series of data surprises (Boesler, 2013). A positive reading suggests that data releases have on balance been higher than median survey expectations.[12]

First, we estimate the response of monthly (weekly) changes in long-term derived mean inflation expectations (in basis points), $\Delta\pi_t^{5/5}$, to both domestic (esi_t) and global (esi_t^g) economic surprise indices, according to

$$\Delta\pi_t^{5/5} = c_0 + c_1 esi_t + c_2 esi_t^g + \epsilon_t \tag{15}$$

using Newey-West adjusted standard errors to correct for serial correlation and heteroscedasticity, and we estimate the regression separately for monthly and weekly data. For the Czech Republic, Hong Kong and Singapore, where no domestic economic surprise index is available, we only include the global economic surprise index in the regression.

Next, we also estimate the response of daily changes in long-term derived mean inflation expectations (in basis points), $\Delta\pi_t^{5/5}$, to both economic surprise indices according to equation (15) and their response to daily changes in economic surprise indices according to

$$\Delta\pi_t^{5/5} = c_0 + c_1 d(esi_t) + c_2 d(esi_t^g) + \epsilon_t \tag{16}$$

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[12] The effect of Citigroup economic surprise indices on inflation swaps has recently been studied in Rodriguez and Yoldas (2016) for the United States, the euro area and the United Kingdom, using regressions at weekly frequency.

where *d* is the first-difference operator.

Table 5 presents the estimation output from equation (15) for both monthly and weekly data, with the results for the latter shown in parentheses. For both monthly and weekly data, we find that the coefficients on domestic economic surprise indices are insignificant, except for China and the United States, which have significantly positive coefficients, and for Japan, which counterintuitively has a significantly negative coefficient. We also find that the global economic surprise index is insignificant for all economies, for both monthly and weekly data. These results suggest that long-term inflation expectations have been well-anchored over the past decade in all the economies considered, except possibly for China, Japan and the United States.

Table 5: Responses of long-term derived inflation expectations to economic surprise indices using monthly (weekly) data

	Domestic economic surprise index	Global economic surprise index	Adjusted R^2
Canada	0.015 (0.0001)	0.015 (0.007)	-0.004 (-0.002)
China	0.116* (0.038*)	0.049 (-0.0025)	0.029 (0.005)
Czech Republic	-	-0.039 (-0.008)	0.001 (-0.001)
Euro area	0.006 (0.008)	-0.032 (-0.019)	-0.011 (-0.002)
Hong Kong	-	0.053 (0.008)	-0.0005 (-0.001)
Japan	-0.068** (-0.021***)	-0.063 (-0.003)	0.034 (0.004)
Norway	0.003 (0.001)	-0.078 (-0.015)	0.005 (-0.001)
Singapore	-	0.034 (0.009)	-0.003 (-0.001)
Sweden	-0.001 (0.001)	-0.033 (-0.011)	-0.009 (-0.002)
Switzerland	0.017 (0.003)	-0.038 (-0.006)	-0.003 (-0.002)
United Kingdom	0.022 (0.002)	-0.031 (0.001)	-0.008 (-0.003)
United States	0.146*** (0.030**)	-0.023 (-0.010)	0.094 (0.009)

Notes: OLS regressions for equation (15) using monthly (weekly) data and Newey-West adjusted standard errors, July 2004 to January 2017 (8 June 2004 to 24 January 2017) for monthly (weekly) data. */**/*** indicates significance at the 10/5/1 percent level. Monthly (weekly) changes in long-term derived inflation expectations in basis points. Constant included in regression but not shown

Table 6: Responses of long-term derived inflation expectations to changes (levels) of economic surprise indices using daily data

	Domestic economic surprise index	Global economic surprise index	Adjusted R^2
Canada	0.000169 (0.017569)	0.001528 (0.027612)	-0.001 (-0.0001)
China	0.001983 (0.010421)	-0.000458 (-0.217532)	-0.001 (-0.0002)
Czech Republic	-	-0.000991 (0.026240)	-0.0003 (-0.0002)
Euro area	0.001871 (-0.013054)	-0.003510 (0.124652)	-0.001 (-0.0001)
Hong Kong	-	0.002465 (-0.12716**)	-0.0003 (0.001)
Japan	-0.00421* (0.04376*)	0.000440 (-0.064578)	-0.0005 (-0.000122)
Norway	0.000160 (0.012600)	-0.002052 (0.010717)	-0.001 (-0.000365)
Singapore	-	0.002423 (-0.109142*)	-0.0003 (0.000561)
Sweden	0.00046 (0.028604*)	-0.001898 (0.002674)	-0.0006 (0.00004)
Switzerland	0.000969 (0.002067)	-0.000999 (-0.006254)	-0.001 (-0.001)
United Kingdom	0.000730 (-0.013463)	0.001640 (-0.082408)	-0.001 (-0.000146)
United States	0.00572* (0.08776*)	-0.002220 (-0.054455)	-0.0001 (0.001)

Notes: OLS regressions for equation (15) using daily data and Newey-West adjusted standard errors, 3 June 2004 to 24 January 2017 (for China, from 17 May 2007). Corresponding regressions for equation (16) in parentheses. */**/*** indicates significance at the 10/5/1 percent level. Daily changes in long-term derived inflation expectations in basis points. Constant included in regression but not shown.

Table 6 presents the estimation output for daily data from equation (15) and from equation (16), with the results for the latter shown in parentheses. We find at daily frequency that the coefficients on domestic economic surprise indices are insignificant, except for the United States and for Japan, and for Sweden (when included as changes, but not as levels). We also find that the global economic surprise index is only significant in two cases, when included as changes for Hong Kong and Singapore. These results at the daily frequency also suggest that long-term inflation expectations have generally been well-anchored over the past decade in all the economies considered, except possibly for Japan and the United States.

6.3 Expected long-term real interest rates

A third way to use our derived measures of inflation expectations is to calculate long-term, or equilibrium, real interest rates. Figure 7 presents real interest rates computed as the difference between the 5y/5y forward interest rate swap, which we calculate analogously to equation (10), and respectively, Consensus Economics inflation expectations, the mean of our derived measures of inflation expectations and where available, domestic inflation swap data.

All measures of the long-term real rates display a clear downward trend, with the only exception being the Chinese series constructed using Consensus Economics data. In most cases, real rates were approximately 3% at the beginning of the sample in 2004. At the end of the sample they were typically approximately 0%.

In terms of monetary policy, these estimates of the long-term real interest rate suggest that central banks have relatively little space to raise nominal rates. Assuming an inflation objective of 2% and an equilibrium real rate of 0% implies an equilibrium nominal rate of 2%. If the policy rate is increased above

2%, monetary policy becomes restrictive. This compares with a situation at the beginning of the sample when the equilibrium real rate was approximately 3% and a nominal interest rate of 5% would have implied a neutral policy stance. The distance to the effective lower bound has according to this analysis shrunk by 3 percentage points.

7. Conclusions

Long-term inflation expectations matter for markets and central banks. We derive daily market-based long-term inflation expectations for eight countries without inflation swap markets, using PPP, UIP (and CIP). Our derived measures seem plausible since they move closely with long-term inflation expectations reflected in domestic inflation swaps in countries where such markets exist. These market-based measures display more variation than survey expectations. Since we compute a number of measures per country, we also gain a sense of the range of expectations and thus of uncertainty about future inflation.

We think the derived measure is a useful tool for central banks, financial markets and researchers, and we illustrate potential uses. Preliminary estimates suggest that long-term inflation expectations do not contain information for actual inflation. However, short-term expectation might, and the approach presented could be used to compute shorter-term market expectations. Our derived measures of long-term inflation expectations can also be used to assess central bank credibility. If one defines long-term inflation expectations as being well-anchored if they do not respond to economic news, our preliminary results suggest that long-term inflation expectations have generally been well-anchored over the past decade. Finally, our measures of long-term inflation expectations can be used to compute long-term real interest rates. We find a clear downward trend in long-term real interest rates across countries. This implies less room globally for manoeuvre for central banks.

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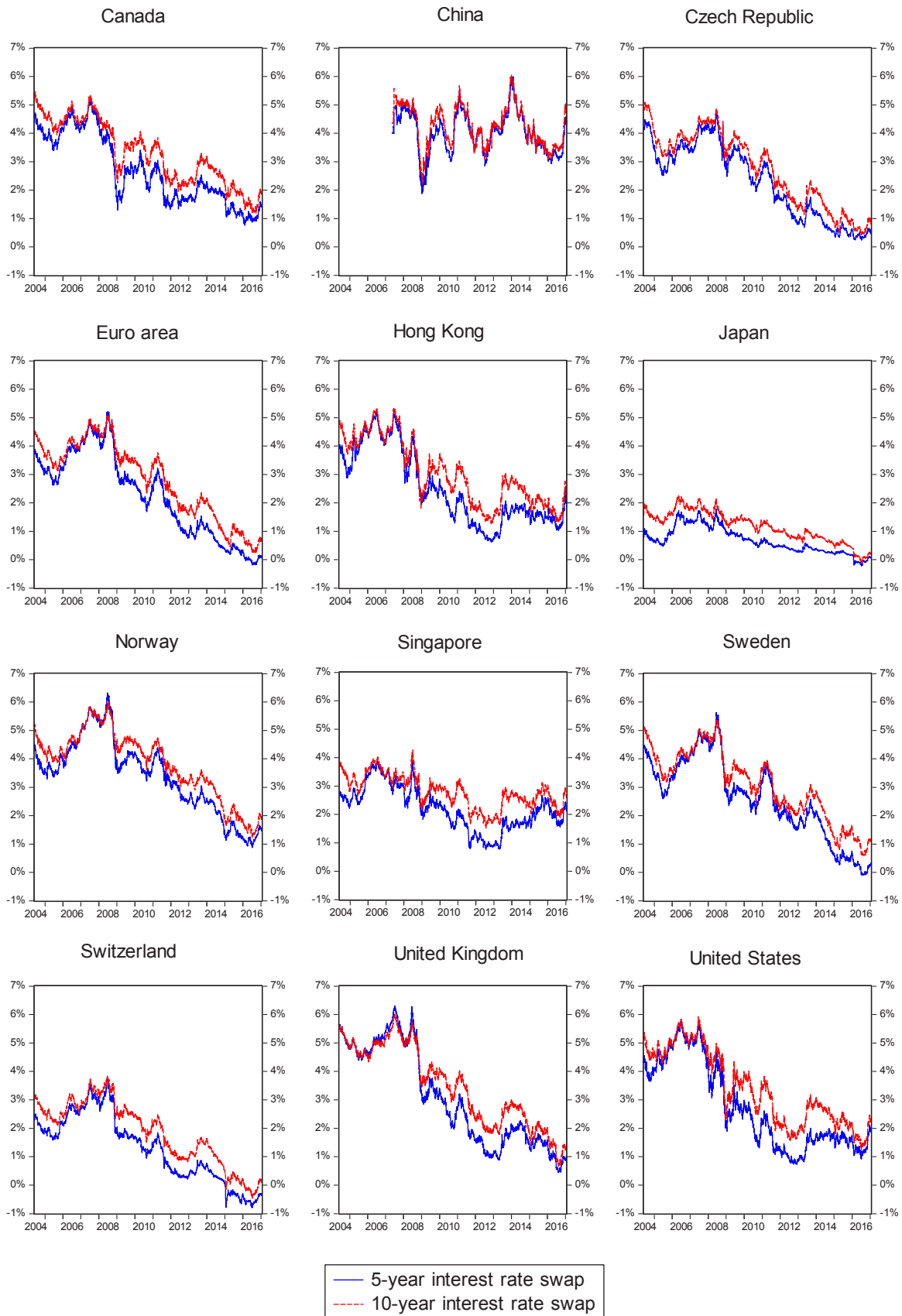
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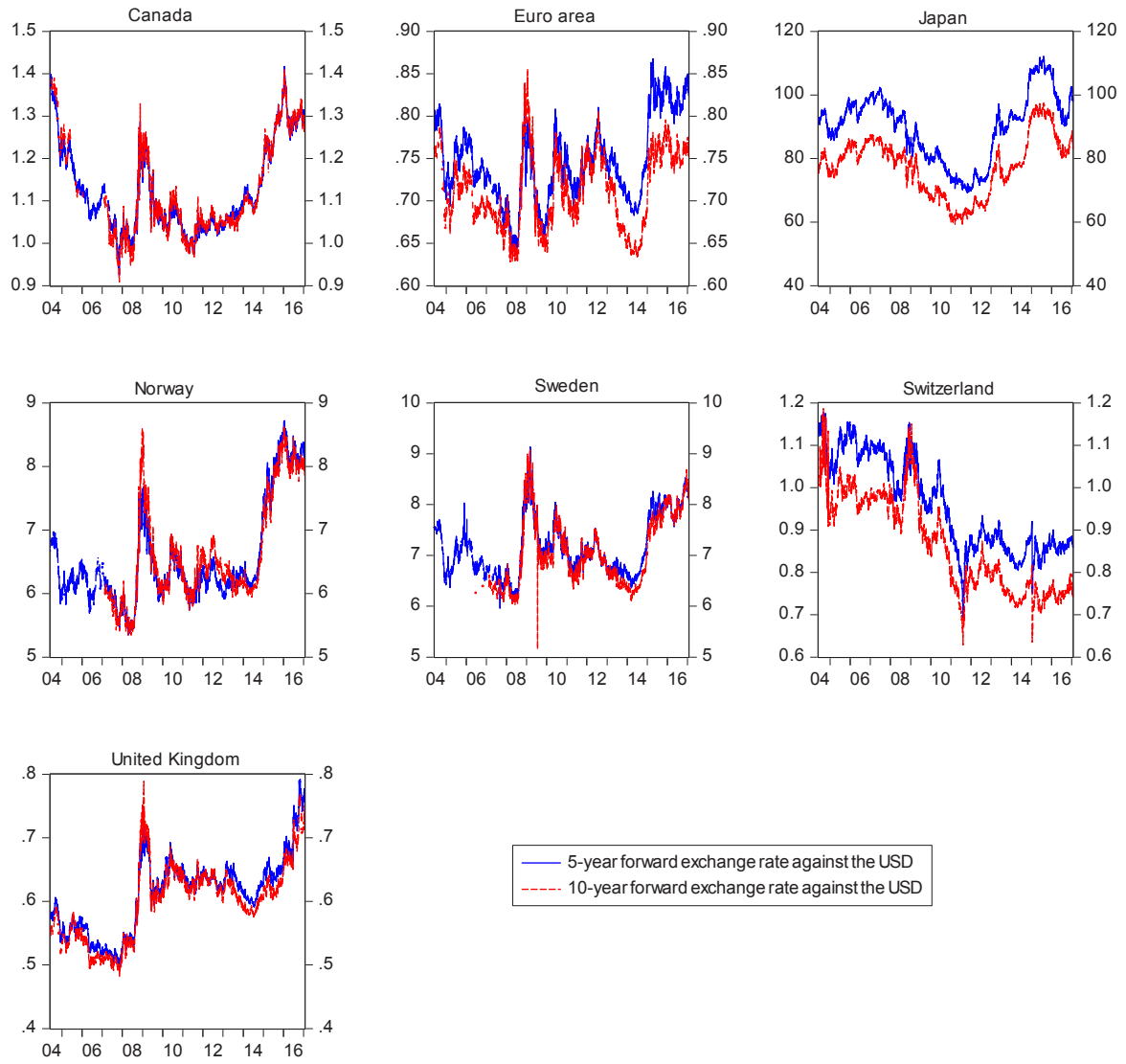Zhu, F. (2016), Understanding the changing equilibrium real interest rates in Asia- Pacific, BIS Working Papers 567.
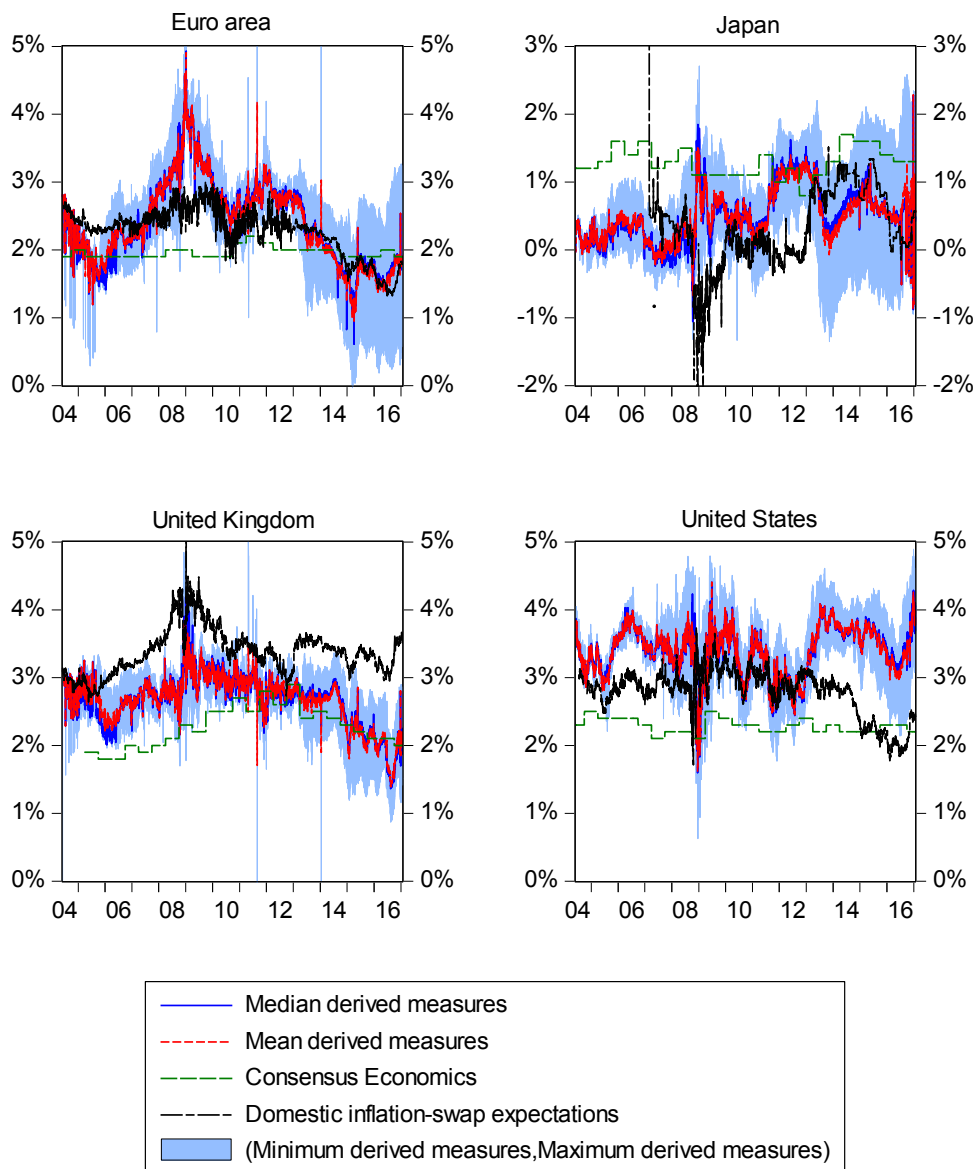
Figures

Figure 1: Interest rate swaps

Canada

China

Czech Republic

Euro area

Hong Kong

Japan

Norway

Singapore

Sweden

Switzerland

United Kingdom

United States

— 5-year interest rate swap
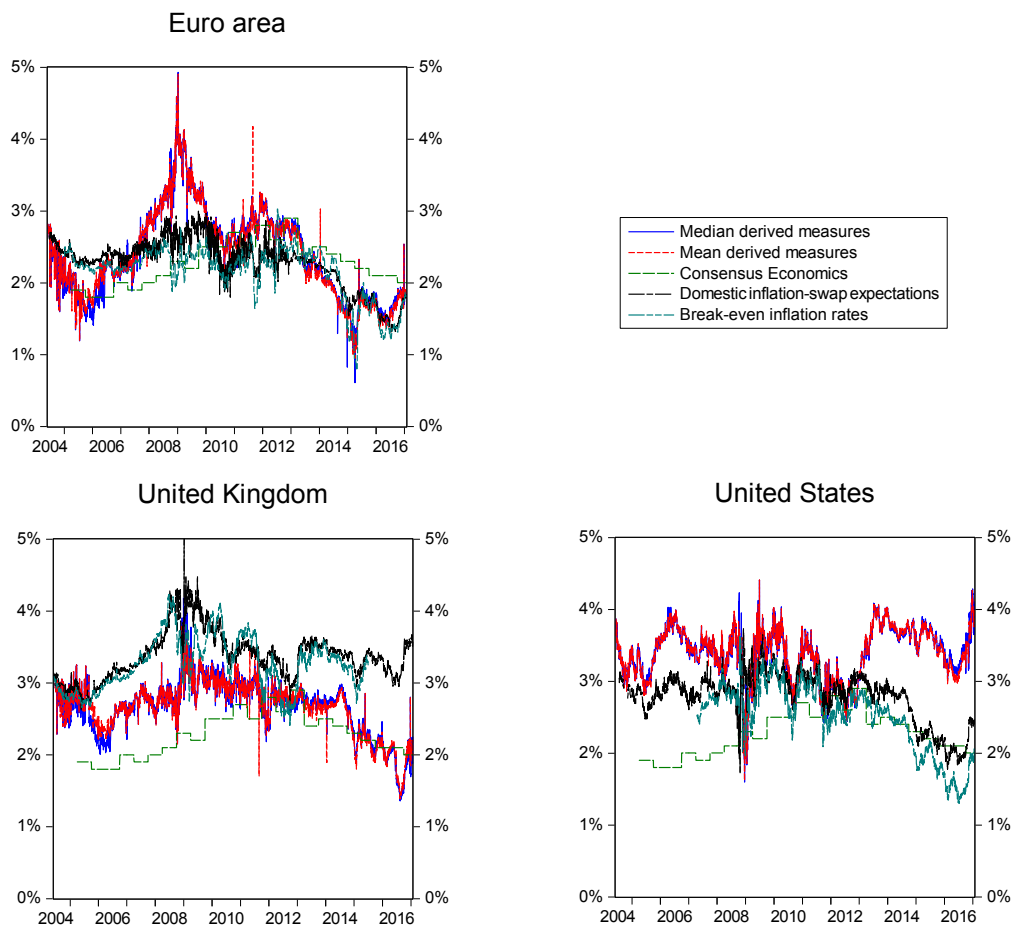---- 10-year interest rate swap

Source: Bloomberg

Figure 2: Forward exchange rates against the USD

Sources: Bloomberg, authors' calculations

Figure 3: Long-term inflation expectations (5y/5y forward), euro area, Japan, United Kingdom and United States

Sources: Bloomberg, Consensus Economics and authors' calculations.

Figure 4: Long-term inflation expectations (5y/5y forward), euro area, Japan, United Kingdom and United States, with break-even inflation rates

Euro area

Legend:
- Median derived measures
- Mean derived measures
- Consensus Economics
- Domestic inflation-swap expectations
- Break-even inflation rates

United Kingdom

United States

Sources: Bloomberg, Consensus Economics, Bank of England, Federal Reserve website, BIS calculations, authors' calculations.

Figure 5: Long-term inflation expectations (5y/5y forward), Canada, Norway, Sweden and Switzerland
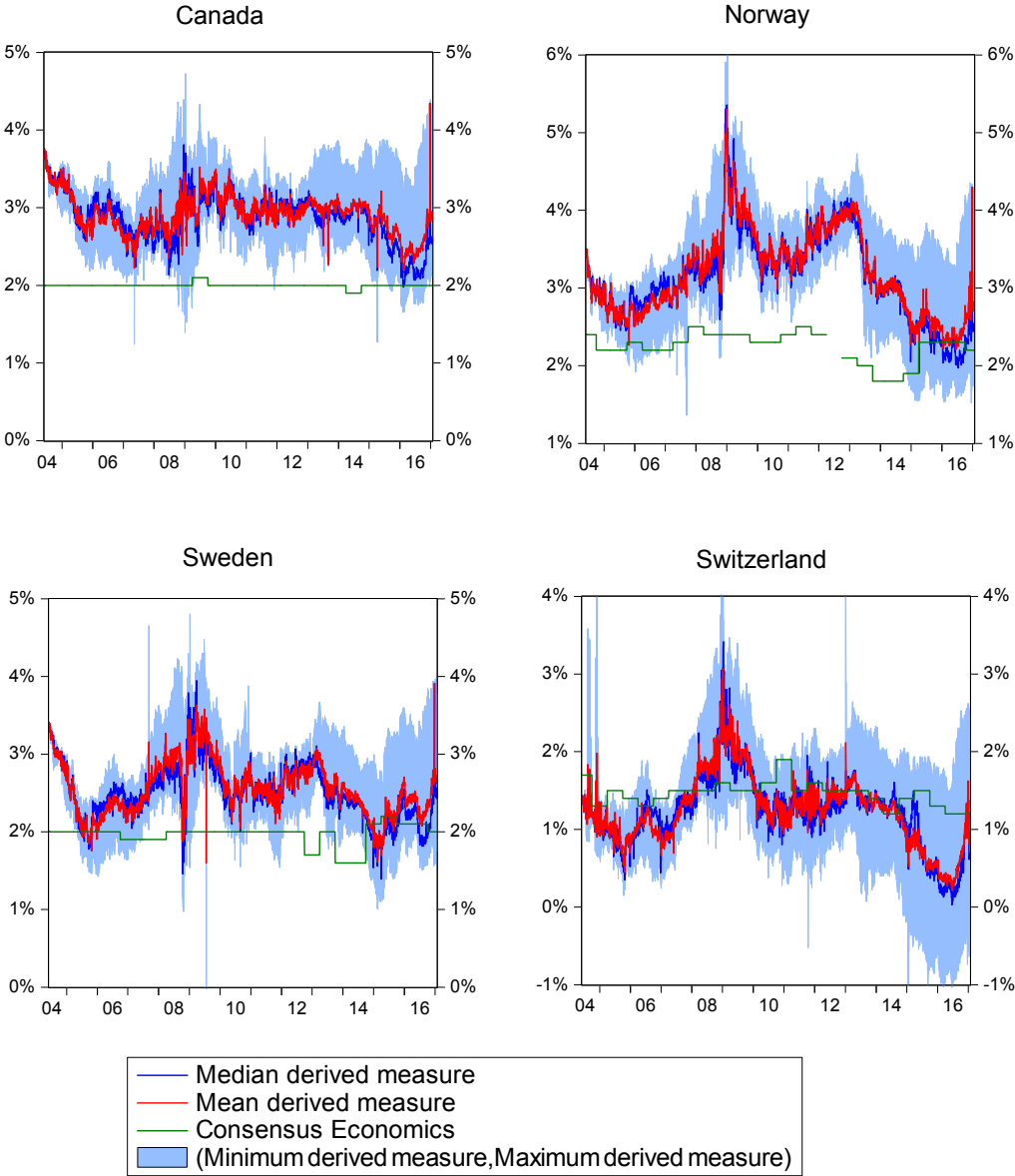
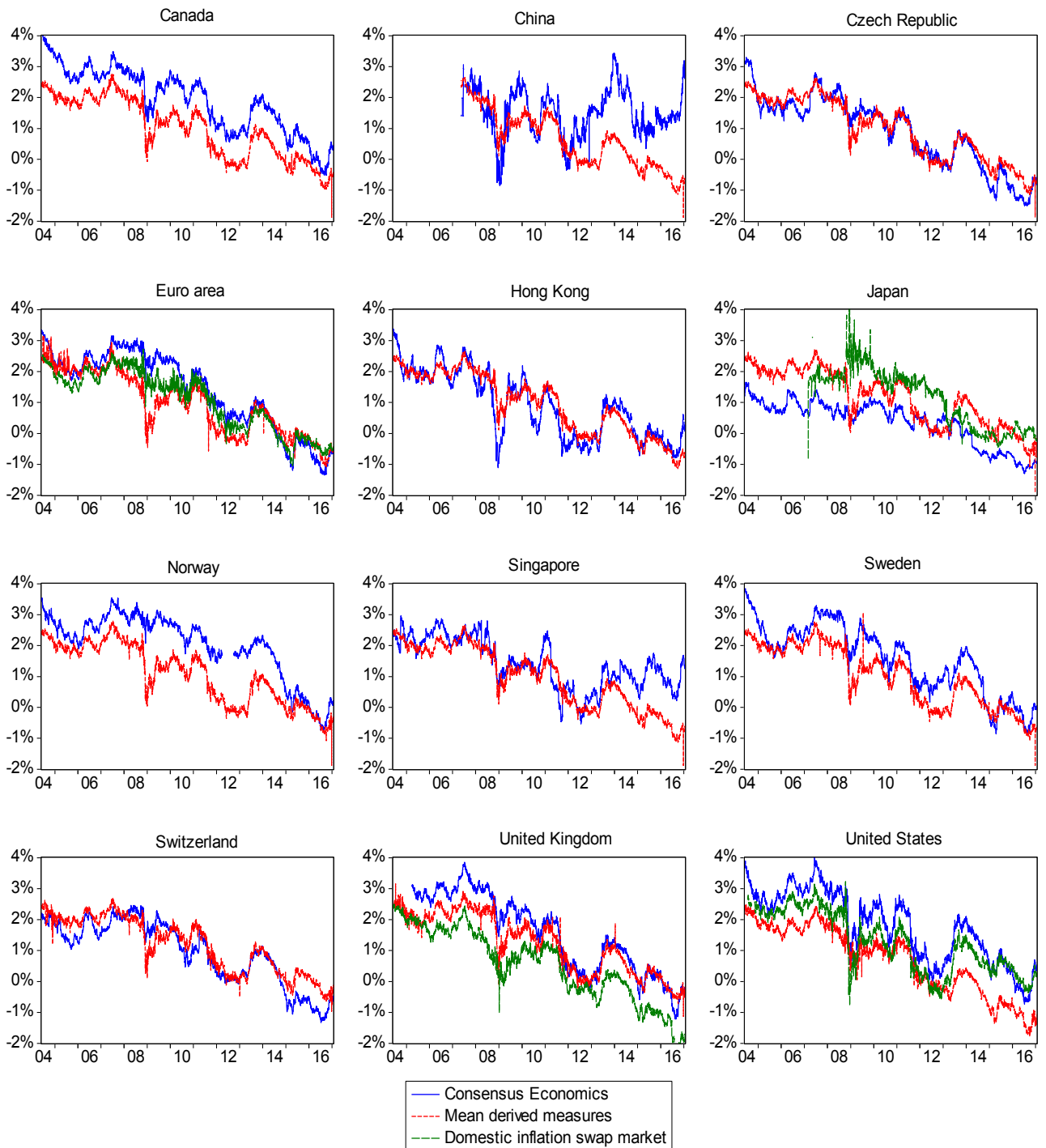Sources: Bloomberg, Consensus Economics and authors' calculations.

Figure 6: Long-term inflation expectations (5y/5y forward), China, Czech Republic, Hong Kong and Singapore
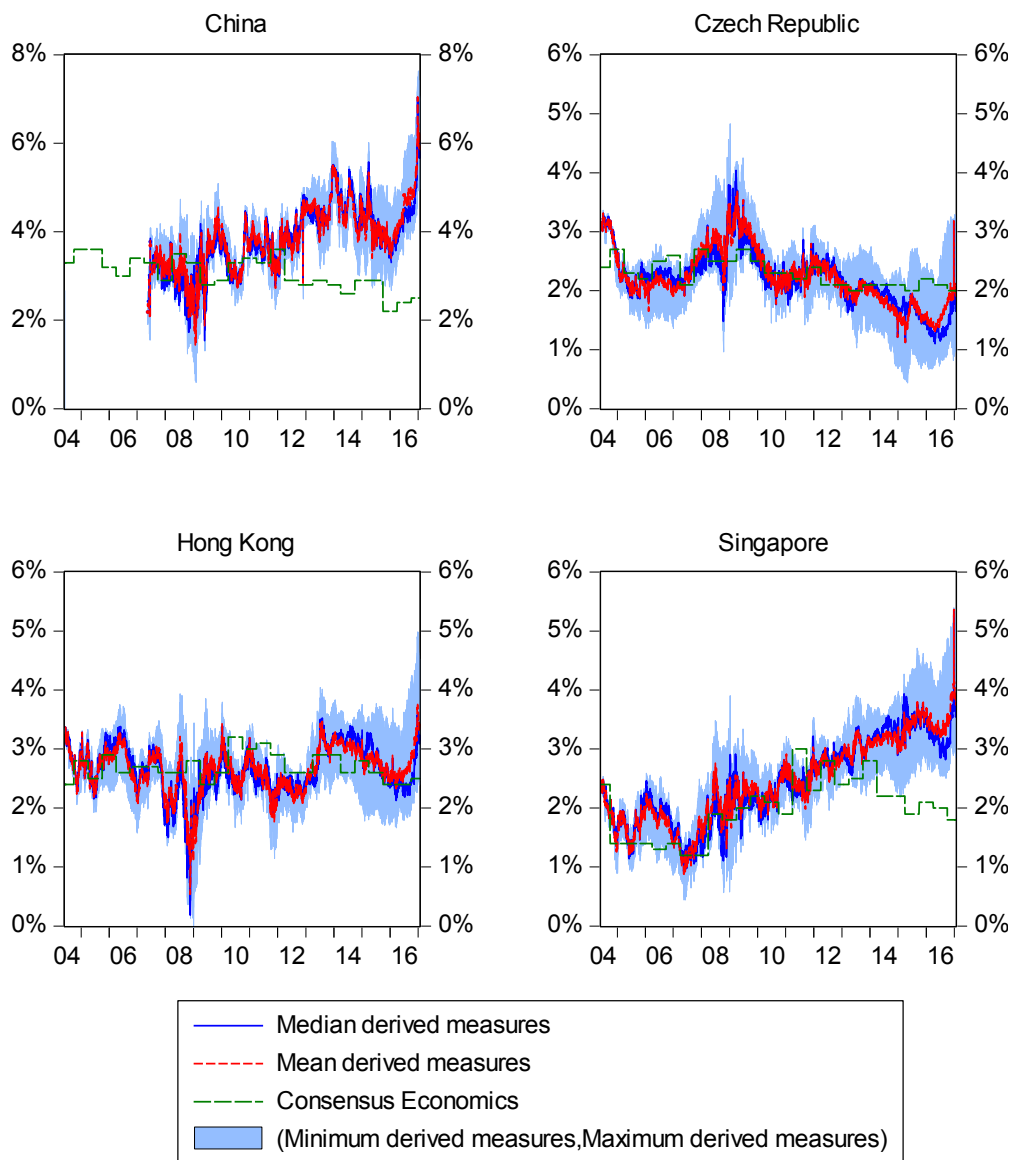
Sources: Bloomberg, Consensus Economics and authors' calculations.

Figure 7: Real interest rates (5y/5y forward) computed using 5y/5y forward interest rate swaps and different measures of long-term inflation expectations
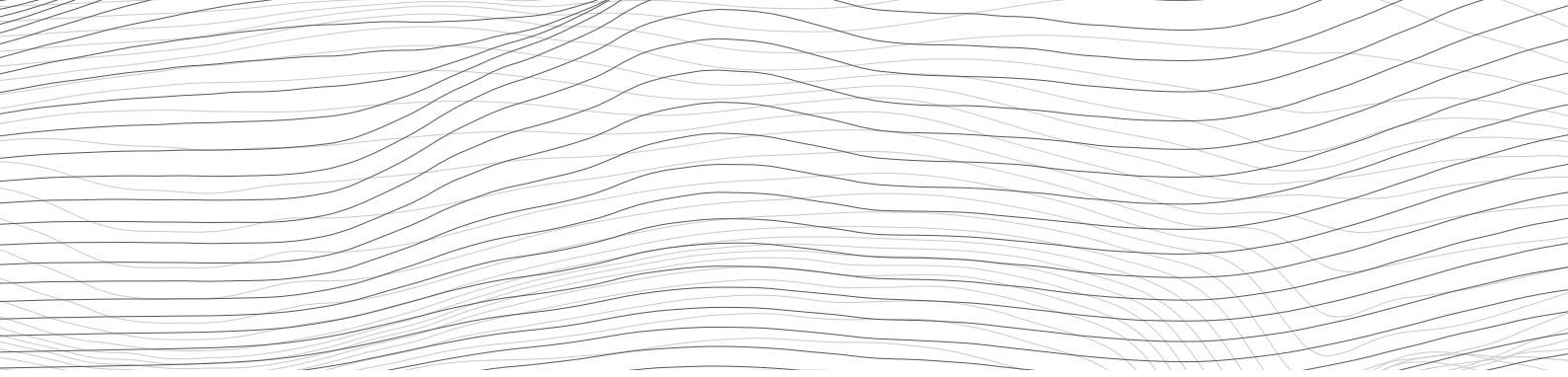

Sources: Bloomberg, Consensus Economics and authors' calculations.

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