Monetary Policy and Stock Market Valuation*

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This paper estimates the effect of monetary policy on the term structure of stock market risk premia. The implied stock market risk premia are obtained using analysts' dividend forecasts and dividend future prices. The effect of monetary policy on risk premia is analyzed using local projections and VAR models. According to the results, monetary policy easing raises the average risk premium. The effect is driven by a rise in long-horizon risk premia.

JEL Codes: E52, G12.

1. Introduction

The notion that the value of a stock is the present value of its expected future dividends goes back at least to Williams (1938). Hence, the changes in stock prices must be explained by either changes in dividend expectations or changes in discount rates. The discount rate, or (approximately) expected rate of return, can be thought of as a sum of a risk-free rate and a risk premium. Hence, monetary policy should have an effect on stock prices through the risk-free rates which it partly controls. Monetary policy may also affect dividend expectations for example through the output of firms (e.g., Galí and Gambetti 2015).

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The effect of monetary policy on the risk premia is, however, less clear. There are reasons to believe that expansionary monetary policy lowers the risk premia, as many papers provide empirical evidence that expansionary monetary policy generates an immediate rise in equity prices followed by a period of lower-than-normal excess returns (e.g., Bernanke and Kuttner 2005). There are also some papers that provide potential explanations for this empirical observation (e.g., Gust and López-Salido 2014). On the other hand, there are many reasons to believe that expansionary monetary policy does not necessarily lower the risk premia. For example, Caballero and Farhi (2013, 2018) argue that asset purchases may raise stock market risk premia by decreasing the supply of negative-beta assets. In addition, expansionary monetary policy may increase risk premia by affecting inflation (e.g., Modigliani and Cohn 1979; Schotman and Schweitzer 2000). Assuming that stock market bubbles exist, Galí (2014) shows that monetary policy easing may decrease the size of stock market bubble (which means increasing risk premia in the framework of this paper). Monetary policy may also affect differently the different parts of the equity risk premium curve that is used to discount the future dividends. For example, Binsbergen et al. (2013) show that empirically the slope of the curve changes over the business cycle.

In this paper I analyze the effect of monetary policy on the term structure of equity premia in order to better understand developments in stock market valuation after the global financial crisis and during the era of unconventional monetary policy measures. As a preliminary analysis, I solve for the implied risk premium using a dividend discount model and analysts' forecasts for the future dividends of the major euro zone stocks that are included in the Eurostoxx 50 index.[1] This approach yields an approximation of the time-varying average long-term equity premium. Then I move to the main topic of this paper: the term structure of equity premia. I combine the prices of Eurostoxx 50 dividend futures with the analysts' dividend forecasts to calculate horizon-specific risk premia using the framework

[1]A kindred approach has been used by, e.g., Claus and Thomas (2001), Gebhardt, Lee, and Swaminathan (2001), and Damodaran (2020). None of these studies, however, provides empirical analysis of the impact of monetary policy on the risk premium.

of Binsbergen et al. (2013).[2] I then analyze the impact of monetary policy on the term structure of equity premia. To the best of my knowledge, this has not been done in the earlier literature.

The effect of monetary policy on the risk premium is interesting, as it may give information about the effect on investors' perception of risk. Thus, the issue is highly relevant for the risk-taking channel of monetary policy.[3] On the other hand, the effect on the implied risk premium may give information about the effect of monetary policy on stock market bubbles or mispricing as the premium captures also the potential bubble component.[4] Therefore, the paper also contributes to the literature studying the effect of monetary policy on stock market bubbles (e.g., Galí 2014; Galí and Gambetti 2015). However, in this paper, I do not attempt to distinguish whether the variation in the implied premium is due to mispricing or variation in the rational risk premium.

From the perspective of firms, equity premium represents a large share of the cost of capital. Therefore, the effect of monetary policy on the implied risk premium is crucial when it comes to the transmission of monetary policy to the investments of firms. For example, the results by Liu, Mian, and Sufi (2022) suggest that the aggregate risk premium may behave differently when interest rates are low due to heterogeneity of firms. Finance literature has also shown that high expected profitability of firms is related to high excess returns (Hou et al. 2021a, 2021b). Therefore, monetary policy may affect implied risk premia also by affecting the expected profitability of firms.

I analyze the effects of monetary policy with two methods. First, I study the effects using local projections, where changes in the overnight index swap (OIS) rates around European Central Bank

[2]Dividend futures have been used recently in many other applications as well. See, for example, the paper by Gormsen and Koijen (2020). In this paper, I focus on the euro area, because the available time series regarding the prices of dividend futures in the United States is very short. When it comes to estimation of horizon-specific premia, alternative approach that applies credit default swap spreads is proposed by Berg (2010) and Berg and Kaserer (2013).

[3]See, for example, the paper by Borio and Zhu (2012) about the risk-taking channel of monetary policy.

[4]The variation in the implied premium means that stocks are sometimes too expensive or too cheap for an investor whose required premium over the risk-free rate is constant over time (or whose required premium varies less than the implied premium).

(ECB) Governing Council announcements are used as a proxy for monetary policy shocks.[5] In the second approach, which serves as a robustness check, I study the effects in a vector autoregressive (VAR) model in which monetary policy stance is measured using the shadow (policy) rate, taking into account the zero lower bound of the policy rate.[6] The monetary policy shock is identified using sign restrictions.

The results show that the average risk premium has increased considerably since the global financial crisis, and this change is driven by the change in long-horizon premia. The results show that monetary policy easing has had a positive and persistent impact on the average and long-horizon risk premia. At the same time, it is true that monetary policy easing decreases short-horizon risk premia (in line with, e.g., Bernanke and Kuttner 2005). This implies that expansionary monetary policy steepens the slope of the term structure of risk premia.

These results indicate that "leaning against the wind" policies are ineffective when it comes to the stock market. Contractionary monetary policy increases the short-term premia but decreases long-horizon premia. The effect on average risk premium is negative. Thus, monetary policy tightening makes stocks "expensive" in relation to the expected stream of dividends and the level of risk-free rates. The results provide no evidence that expansionary monetary policy causes stock market bubbles.

The underlying theoretical mechanism explaining the results is likely to be complex. The results do not seem to support inflation-based explanations. When it comes to the mechanism described by Caballero and Farhi (2013, 2018), the results do not contradict this explanation, but more careful research is needed to draw any further conclusions. Another potential explanation that should be examined in the future research is "bubbles in dividend forecasts": the equity analysts' forecasts may be systematically too optimistic or

[5] Intraday OIS rate changes are obtained from the EA-MPD (Euro Area Monetary Policy event study Database): https://www.ecb.europa.eu/pub/pdf/annex/Dataset_EA-MPD.xlsx?afecc88fe2e29c7abcdee5670b6d0f68. See the paper by Altavilla et al. (2019).

[6] The concept of shadow rate was first introduced by Black (1995).

pessimistic after the monetary policy shocks. All in all, the contribution of this paper is to provide stylized facts and raise questions rather than provide definitive answers.

The remainder of the paper is as follows. Section 2 explains the theoretical framework and empirical strategy. It is divided into three subsections. The first presents the general theoretical model, the second the empirical strategy, and the third briefly reviews the main results of the previous literature. Section 3 presents the data and explains the econometric methods. It is also divided into three subsections: the first explains the construction of time-varying risk premia and the latter two explain the econometric methods to analyze how monetary policy affects the risk premia. Section 4 shows the local projection and VAR results. Section 5 provides some additional results that may guide the future research. Section 6 concludes.

2. Monetary Policy and Equity Premia

2.1 Theoretical Framework

The value of a stock at time 0 can be expressed as

$$P_0 = E_0 \left[\sum_{t=1}^{n} m_{0,t} D_t + m_{0,n} P_n \right], \tag{1}$$

where $m_{0,t}$ is the stochastic discount factor and D_t is the expected dividend. The specific form of the $m_{0,t}$ depends on the assumptions regarding the investors' preferences. An alternative expression for the stochastic discount factor is $m_{0,t} = \prod_{i=1}^{t} \frac{1}{(1+r_i)}$, where r_i is the required rate of return.[7] Risk premium is the difference between the required rate of return and the risk-free rate: $r_i^{excess} = r_i - r_i^{risk-free}$.

2.2 Solving for the Implied Risk Premia

I use two approaches to solve for the implied risk premia. The first one gives an approximation of the long-run average premium (see,

[7]This expression follows from the definition of return: $r_1 = \frac{P_1 - P_0 + D_1}{P_0}$. This can be rearranged as $P_0 = \frac{D_1 + P_1}{1+r_1}$. Using rational expectations, one can solve this forward: $P_0 = E_0\left[\frac{D_1}{1+r_1} + \frac{D_2+P_2}{(1+r_1)(1+r_2)}\right]$. Here, for example, $\frac{1}{(1+r_1)(1+r_2)} = m_{0,2}$.

e.g., Fama and French 2015). The second one allows me to solve for the horizon-specific premia.

For the first approach, I assume that expected dividends, D_t, grow at constant rate, g, after the period n and that the discount rate, r, is the same for all the horizons. This r approximates the (time-varying) long-run average required rate of return. With these assumptions, Equation (1) simplifies to

$$P_0 = E_0\left[\frac{D_1}{1+r} + \frac{D_2}{(1+r)^2} + \cdots + \frac{D_n}{(1+r)^n} + \frac{\frac{D_{n+1}}{r-g}}{(1+r)^n}\right]. \qquad (2)$$

If the market price of the share and the dividend expectations are known, r can be solved numerically period after period. This gives an approximation of how the expected long-run average return varies over time. Subtracting some proxy for the risk-free rate gives an estimate for the risk premium

The second approach relates dividend expectations to the prices of dividend future contracts. Dividend futures are contracts that allow one to buy the dividends of a specific year.[8] The cash flows are paid at the end of the year. Assuming no arbitrage, the price of the dividend future at time 0 that matures after h years is given by[9]

$$F_{0,h}^{DivFut} = e^{-\sum_{i=1}^{h} r_i^{excess}} E_0[D_h]\,. \qquad (3)$$

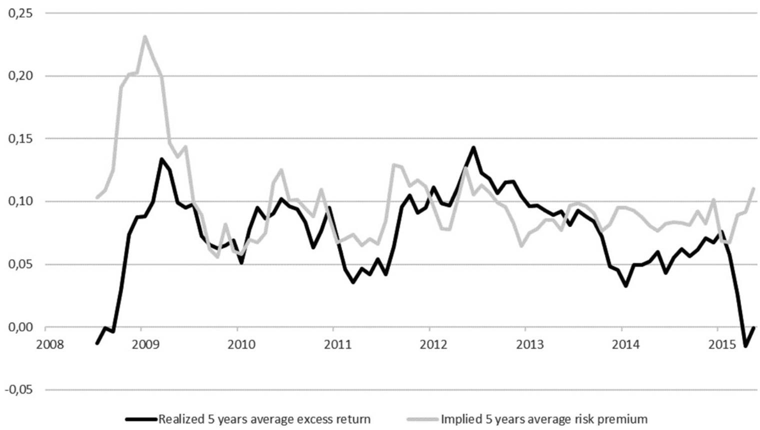
The discount rate is equal to the premium, r_i^{excess}, because the cash flows are paid at the maturity.[10] This means that the future contract does not tie up money. Thus, the buyer of the future receives the risk-free return in excess to the return of the future contract. The price of the dividend future, considering the dividends of the next 12 months, is $F_{0,1}^{DivFut} = e^{-r_1^{excess}} E_0[D_1]$. Accordingly, the price of the future considering the dividends 12 to 24 months ahead is

[8] Wilkens and Wimschulte (2010) and Lamponi and Latto (2017) provide a good overview of these instruments and their pricing.

[9] See Binsbergen et al. (2013) for details.

[10] For example, the future or forward price (the price one observes) of a dividend future contract maturing after one year is $F_{0,1}^{DivFut} = e^{-(r_1^{risk-free}+r_1^{excess})} E_0[D_1]\, e^{r_1^{risk-free}} = e^{-r_1^{excess}} E_0[D_1]$. See also Binsbergen et al. (2013, pp. 504–5).

Figure 1. Expected and Realized Stock Market Premia of Eurostoxx 50 Index



Note: The expected premia are based on analysts' dividend forecasts, Eurostoxx 50 dividend futures, and application of Equation (3). More details are given in Section 3. The realized return is calculated from log-differences of Eurostoxx 50 gross return index, which takes into account paid dividends. The German one-year yield is used as the risk-free rate measure.

$F_{0,2}^{DivFut} = e^{-(r_1^{excess}+r_2^{excess})}E_0[D_2]$ and so forth. Therefore, knowing the prices and the dividend expectations, one can solve horizon-specific expected premia beginning from r_1^{excess}.

2.3 The Role of Monetary Policy

The previous literature has focused on analyzing the effect of monetary policy on excess returns rather than on risk premia implied by dividend expectations (e.g., Patelis 1997; Bernanke and Kuttner 2005).[11] Implied risk premia and realized excess returns are related, but the two may sometimes differ considerably. Figure 1 shows the development of implied five-year average stock market risk premia based on Equation (3) together with the realized stock market excess return.[12] For example, during the financial crisis of

[11]For example, Bernanke and Kuttner (2005) consider expected future excess returns (risk premia) given by an econometric model.
[12]Details about empirical implementation are given in Section 3.

2008 investors were pricing a roughly 20 percent risk premium. Yet, the actual realized excess returns were much lower. Thus, realized excess returns after the financial crisis tell little about stock market valuation during the financial crisis. For the purpose of this paper, it would probably be more interesting to see what happens after 2015. In January 2015, the ECB's large-scale asset purchase program (APP) was extended to include purchases of sovereign bonds. After this policy, the implied stock market premium rose, and the realized excess returns were very low.

This potentially surprising observation is consistent with the argument by Caballero and Farhi (2013, 2018) that buying sovereign debt may increase the stock market risk premium. They note that "long term public debt, by being a 'bearish' asset that can be used to hedge risky private assets, has a safe asset multiplier effect that short term public debt lacks. That is, long term public debt is not only a safe asset in itself, but also makes risky private assets safer through portfolio effects."

Another potential mechanism through which monetary policy easing may increase stock market risk premia is inflation. Theoretically, one may argue that inflation is irrelevant for the premium, because it affects equally to expected nominal dividends and nominal risk-free rates. This is not true empirically. For example, Modigliani and Cohn (1979) and Schotman and Schweitzer (2000) have shown empirically that inflation matters for the stock market risk premium. Therefore, one mechanism could be that expansionary monetary policy raises the expected future inflation, which in turn makes investors require higher risk premia for the future dividends.

On the other hand, if one assumes that stock market bubbles exist, it is possible that monetary policy easing decreases the size of stock market bubble (Galí 2014; Galí and Gambetti 2015). In their papers, Galí (2014) and Galí and Gambetti (2015) use the risk-neutrality assumption and interpret all deviations from risk-free return as a bubble. In my paper, no assumptions regarding the risk attitude of investors are made. Therefore, my results can be interpreted also in the risk-neutral framework of Galí (2014): higher implied premium means smaller stock market bubble. One could argue that the monetary policy easing by the ECB decreased stock market bubble through the mechanism described by Galí (2014).

The conventional wisdoms that monetary policy easing lowers stock market risk premia and/or creates bubbles is motivated primarily by empirical results based of realized excess returns (e.g., Patelis 1997; Bernanke and Kuttner 2005). However, the theoretical mechanisms driving these results are not clear.[13] In addition, as discussed above, there are multiple reasons to presume that expansionary monetary policy raises rather than lowers stock market risk premia. In this paper, I challenge the conventional wisdoms that are based on empirical results by a set of new empirical results. Unlike in the previous literature, I do not analyze realized excess returns but implied risk premia. This approach allows me to focus on the whole term structure of risk premia that is used to discount the future dividends.

3. Data and Empirical Methods

3.1 Risk Premia

To solve the implied risk premia, I use Equations (2) and (3). First, I apply Equation (2) to the Eurostoxx 50 stock market index and analysts' consensus forecasts for future dividends. Given the stock market index and aggregated dividend forecasts, I solve the expected annual rate of return, r. Further, the variation in expected return can be divided into variation in risk-free rate and stock market risk premium using some proxy for the risk-free rate. As a proxy for the risk-free rate, I use Germany's 10-year government bond yield following Claus and Thomas (2001), Gebhardt, Lee, and Swaminathan (2001), and Damodaran (2020). The reason for using a long rate rather than a short one is that the rate should represent the average expected risk-free rate[14] The results are about the same even though one uses some other proxy. All these data are from Bloomberg and cover the period from June 2006 to April 2020. The reason for using this sample is the availability of data about analysts' dividend forecasts.

[13] See, for example, the discussion by Galí (2014) and Galí and Gambetti (2015).

[14] Alternatively, one could use different interest rates for different horizons. However, Claus and Thomas (2001) conclude that the results are almost identical. Therefore, for the sake of transparency, I use one interest rate.

I obtain monthly data about year-specific dividend forecasts from Bloomberg. The forecasts are at the index level. The index-level forecasts are weighted averages across individual sell-side analysts' firm-specific forecasts. The weights are the same as those that are used to form the stock index. One company is followed by approximately 30 analysts. The large number of analysts per company is one benefit from using Eurostoxx 50 rather than some broader index. I calculate the 12- and 24-month forward dividend expectations (D_1 and D_2) as a weighted average of year-specific forecasts.[15] Additionally, analysts' forecast average earnings per share growth rate after three to five years. I assume that dividend payout ratio remains constant, meaning that earnings per share growth rate can be used to calculate dividends: D_3, D_4, D_5, and D_{5+1}.[16] I assume that the expected long-run dividend growth rate, g, equals the historical average of the analysts' expected earnings per share growth rate in the sample (4.5 percent).[17]

With these assumptions, the only unknown variable in Equation (2) is r. This variable can be solved for every month in the sample. Subtracting Germany's 10-year government bond yield, I get an estimate for the expected average annual stock market premium in each month. The developments of the expected rate of return and expected premium are presented in Figure 2.

In the sample the average expected premium, r^{excess}, is 7.3 percent and the average expected return, r, is 9.0 percent. These results are in line with the previous estimates based on a similar methodology.[18] Notably, the expected rate of return for equities has remained

[15]For example, I calculate the 12-months-ahead dividend forecast in April 2020 as follows: (8 $*$ *Dividend forecast for the year* 2020 + 4 $*$ *Dividend forecast for the year* 2021)/12.

[16]As the data about the average future earnings per share growth rate are rather noisy, I use a 12-month moving average to smooth the series. In addition, I remove clearly unrealistic extreme values (values below –30 percent and greater than 30 percent).

[17]This assumption affects mainly the level of risk premium, but not so much the variation of premium. It is also possible that there has been variation in the expected long-run growth. This issue is assessed in Appendix B. The results show that the long-run growth rate expectation should have declined more than 4 percentage points after the financial crisis to affect the conclusions of this paper.

[18]Claus and Thomas (2001) and Gebhardt, Lee, and Swaminathan (2001) find that the average expected premium has been around 3 percent. However, recent

Figure 2. Solved Expected Rate of Return and Expected Premium

Note: The variables are solved applying Equation (2) to Eurostoxx 50 stock market index and analysts' consensus forecasts in the period from June 2006 to April 2020.

rather stable since the 2008 financial crisis, even as risk-free rates have declined substantially. This means that the expected premium over the risk-free rates has increased considerably since the crisis.[19]

As was discussed earlier, expected returns differ across discounting horizons. To solve the horizon-specific risk premia, I apply Equation (3) to the prices of Eurostoxx 50 dividend futures and analysts' dividend forecasts. A bit similar approach is used by Binsbergen

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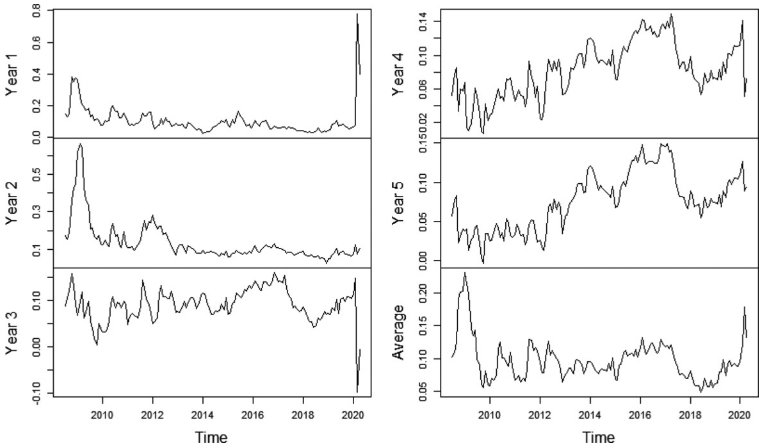
estimates by Damodaran (2020) for the S&P 500 are quite similar to my results. The estimates for the S&P 500 suggest that the expected premium can deviate from its long-run average for many years. The expected premium in the United States was quite high during the 1970s and quite low during the 1990s (consistently with the results of Claus and Thomas 2001 and Gebhardt, Lee, and Swaminathan 2001). After the financial crisis, the expected premium has been very high in the United States and has exhibited an upward trend like in Europe.

[19]One potential explanation for this is that the long-run expected dividend growth rate, g, which is assumed constant, has declined. Appendix B studies this potential explanation. The results show that it is unlikely that the decline in very long-run expectations would explain the result. If one argues that the equity premium has not risen, it would mean that the long-run expected growth rate should have declined more than 4 percentage points.

Figure 3. Year-Specific Expected Premia Implied by Eurostoxx 50 Dividend Futures and Analysts' Dividend Forecast from July 2008 to April 2020



et al. (2013).[20] I calculate the prices of one-, two-, three-, four-, and five-year-ahead dividend futures by taking the weighted average of the observed future prices.[21] Then, I calculate the implied expected premia for every horizon beginning from the 12-month discounting horizon. The data about the dividend futures are from July 2008 to April 2020 and have been collected from Bloomberg. The solved expected premia are shown in Figure 3. Key summary statistics appear in Table 1.

In agreement with Binsbergen, Brandt, and Koijen (2012), Binsbergen et al. (2013), and Binsbergen and Koijen (2017), the variation in the expected premia is related mostly to the near future. The standard deviation of the year 1 premium is 0.09 and the standard deviation of the year 5 premium is 0.04. Year 1 premia are on average also higher than year 5 premia. The slope of the premium

[20]The key difference between this paper and the paper by Binsbergen et al. (2013) is that Binsbergen et al. (2013) use regression-based dividend forecasts instead of analysts' forecasts.

[21]For example, I calculate the price of the one-year-ahead dividend future in April 2020 as follows: (8 $*$ *Price of the future maturing in* 2020 + 4 $*$ *Price of the future maturing in* 2021)/12.

Table 1. Summary Statistics of the Year-Specific Expected Premia Implied by Eurostoxx 50 Dividend Futures and Analysts' Dividend Forecast

	Year 1	Year 2	Year 3	Year 4	Year 5
Mean	0.10	0.14	0.09	0.08	0.08
Median	0.08	0.10	0.09	0.08	0.08
SD	0.09	0.11	0.04	0.03	0.04

Note: The observation period runs from July 2008 to April 2020.

curve seems to be procyclical as well. The premium for year 2 has been the highest and the most volatile in this sample. This result is largely driven by the financial crisis, during which the year 2 premium reacted most strongly. This situation has been quite different during the COVID-19 crisis. In March 2020, the year 1 premium climbed to about 80 percent, even as the year 2 premium remained at 8 percent.

One can also see that the premia of years 4 and 5 exhibit similar upward trend as the premium implied by Equation (2). Thus, these results are in line with the earlier conclusion that the average risk premium has increased after the financial crisis. Further, the results suggest that the rise in average premium is mainly driven by long-horizon expected premia.

3.2 Local Projections

I use intraday interest rate changes around the time of ECB Governing Council announcements as a proxy for monetary policy shocks. These rate changes are obtained from EA-MPD (see Altavilla et al. 2019).[22] I use the change in the median quote from the 13:25–13:35 window before the press release to the median quote in the 15:40–15:50 window after the press conference. Assuming these changes represent exogenous variation in the ECB's monetary policy, one can

[22]I assume that the value of the shock was zero if there was no announcement during the month. If there were two announcements, I calculate the average of the two.

assess the effect of monetary policy on different premia by estimating the following model for different horizons:

$$r_{t+h}^{excess} = \alpha_h + \gamma_h (L) r_{t-1}^{excess} + \beta_h Surprise_t + \sum_j^p \delta_{h,j} (L) Control_{j,t-1} + \epsilon_{t+h}. \quad (4)$$

In the model, α_h is a constant, $\gamma_h(L)$ and $\delta_{h,j}(L)$ are lag-polynomials, ϵ_{t+h} is an error term, and $Surprise_t$ is the rate change. The model includes p control variables. I use changes in log(*Industrial production*) and log(*Harmonised Index of Consumer Prices*) as controls. The data about industrial production and consumer prices are from Eurostat. EA-MPD covers surprise changes in many different maturities of OIS rates and government bond yields. In the baseline analysis, I consider the unweighted average of one-week, one-month, three-month, six-month, one-year, two-year, and three-year OIS rate surprises. This average surprise is related to conventional and forward-guidance policies. I use the average rather than some specific maturity, because the aim here is not to disentangle different policy tools but to assess monetary policy "in general."[23] The average is also less noisy than individual rate surprises. The rate surprises in longer maturities are considered in Section 5.3.

As an estimate for risk premium, I consider the premium implied by Equation (2) and the horizon-specific premia implied by dividend futures and Equation (3). The data cover the period from June 2006 to April 2020 except for horizon-specific premia that are not available before July 2008.

The model is estimated using the smooth local projection method by Barnichon and Brownlees (2019).[24]

3.3 VAR Model

My second approach that is used as a robustness check relies on VAR models. A VAR model can be written in reduced form as

$$y_t = c + A(L)y_{t-1} + \mathrm{u}_t, \quad (5)$$

[23]Three-month surprise is used in Appendix C.

[24]To estimate the model and to construct the confidence bands, I use the MATLAB code provided by Barnichon and Brownlees (2019) with their publication.

where y_t is an $n \times 1$ vector of endogenous variables, c is an $n \times 1$ vector of constants, $A(L)$ is an $n \times n$ matrix of lag polynomials, and $u_t = B\varepsilon_t$ is an $n \times 1$ vector of error terms. B is an $n \times n$ matrix that relates error terms to structural shocks, ε_t, which are of interest.

In the baseline model, the stance of monetary policy is measured using the shadow rate proposed by Kortela (2016). The shadow rate permits analysis of the overall effect of monetary policy during a time when policy rates have been close to their effective lower bound. The use of shadow rates has been standard approach in recent macroeconomic literature (e.g., Wu and Xia 2016). In the baseline model, y_t includes year-over-year changes in $\log(Industrial\ production)$ and $\log(Harmonised\ Index\ of\ Consumer\ Prices)$, the level of equity premium and the shadow rate. Industrial production and inflation are included, as the monetary policy decisions are affected by the changes in real activity and price stability. The baseline model includes two lags. Many other model specifications (e.g., models with some other shadow rate estimates, a model in levels and with a different number of lags) are considered in Appendix A and in the online appendix available at http://www.ijcb.org.

I identify monetary policy shock using sign restrictions and the standard rejection method of Rubio-Ramirez, Waggoner, and Zha (2010).[25] I assume that a positive monetary policy shock decreases the growth in industrial production and consumer prices.[26] These sign restrictions are assumed to hold the first nine months. The effect on shadow rate itself is also restricted positive for the first nine months. These restrictions are consistent with, for example, the results by Bernanke, Boivin, and Eliasz (2005) and Wu and Xia (2016). Alternative restrictions are considered in Appendix A and in the online appendix.

[25]The basic idea in sign restrictions is to randomly generate impulse response functions and store the impulse responses that are in line with sign restrictions. To implement the method, I use the MATLAB toolbox by Ferroni and Canova (2020). The documentation of the toolbox explains the practical implementation of the method in more detail.

[26]The model is symmetric, and therefore the opposite applies to a negative shock.

4. Results

4.1 Local Projection Results

Figure 4 shows the estimated responses of different premia to the tightening of monetary policy. The responses of short-term and long-term premia have opposite signs. Contractionary monetary policy raises the year 1 expected premium, while the response of the long-run average expected premium is negative. The negative effect on the average premium implies that a rate hike seems to make stocks expensive in comparison with the expected stream of dividends.

The response of the year 1 premium is consistent with the evidence based on realized returns presented in Bernanke and Kuttner (2005). The signs of the responses of premia at horizons from two to five years vary. Notably, the effect on the long-term average premium suggests that expansionary monetary policy makes the long-run dividend stream riskier (or reduces the size of the stock market bubble). This potentially surprising result supports the idea that mechanisms described in Section 2.3 may play a role.

4.2 Robustness Analysis Using VAR Models

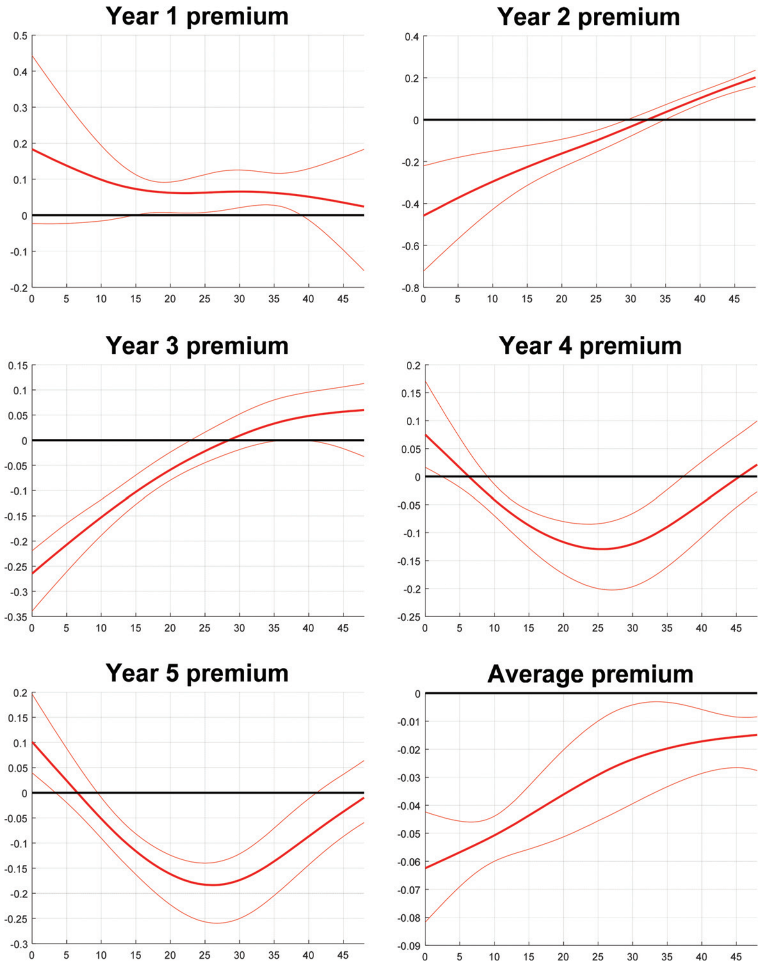
Figures 5, 6, and 7 show the impulse responses to a positive shadow rate shock in three models with different implied premia.[27] In Figure 5, the premium is the one implied by Equation (2). In Figure 6, the premium is the premium for year 1 implied by dividend futures and Equation (3). In Figure 7, the premium is for year 5.

The responses of industrial production and consumer prices comport with the literature (e.g., Bernanke, Boivin, and Eliasz 2005). The responses of short-term and long-term premia have opposite signs. Contractionary monetary policy raises the short-term expected premium temporarily (Figure 6), while the responses of the long-run average expected premium and year 5 premia are negative and persistent (Figure 5, Figure 7).

Whatever the theoretical explanation is, the empirical results are robust (see Appendix A and the online appendix). The results do

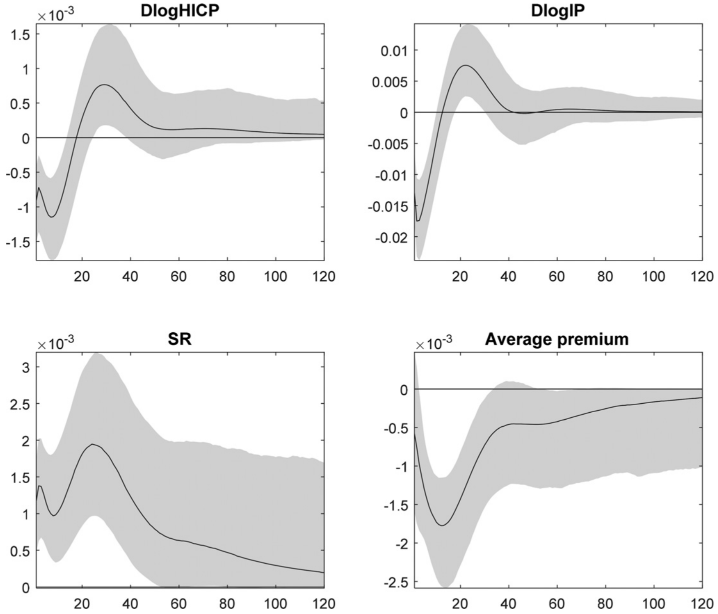
[27]Multiple robustness checks are provided in Appendix A and in the online appendix.

Figure 4. Local-Projection-Based Impulse Response Function of the Year 1, 2, 3, 4, and 5 Premia Implied by Equation (3) and Long-Run Average Expected Premium Implied by Equation (2)



Note: Inflation and the growth rate of industrial production are used as control variables. The number of lags in the model is three. The confidence band is 68 percent. The impulse response functions and their Newey-West-based confidence bands are estimated as in Barnichon and Brownlees (2019).

Figure 5. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium is the Long-Run Average Expected Premium Implied by Equation (2)



Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

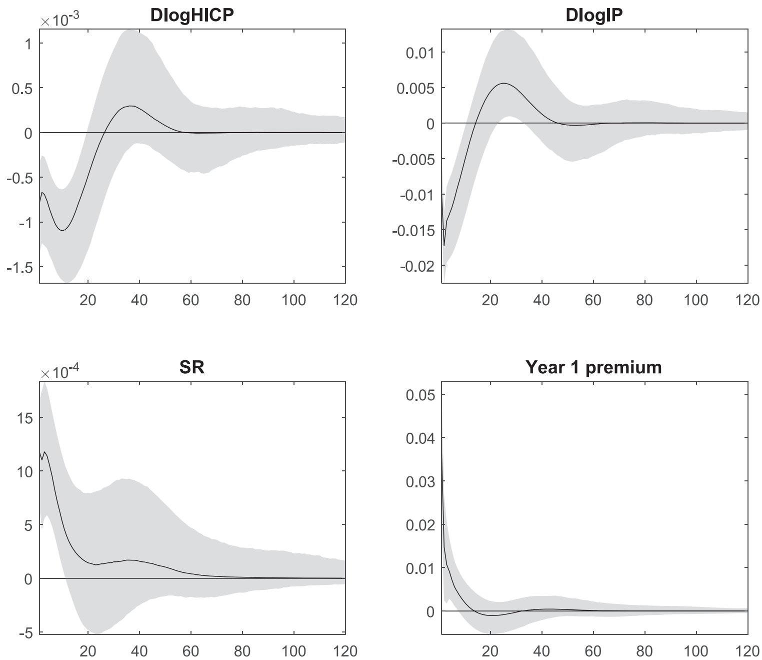
not depend on the model specification or on the used sign restrictions. The chosen shadow rate estimate is not crucial to the results. The results remain the same even though one uses the shadow rate by Krippner (2015) or Wu and Xia (2016). The effects seem not to vary over time.

5. Some Additional Analyses, Remarks, and Suggestions for Future Research

5.1 Long-Run U.S. Data

One may suspect that the results shown in the previous section depend on some specific choices made in the calculation of implied

Figure 6. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Year 1 Premium Implied by Equation (3) and Dividend Futures



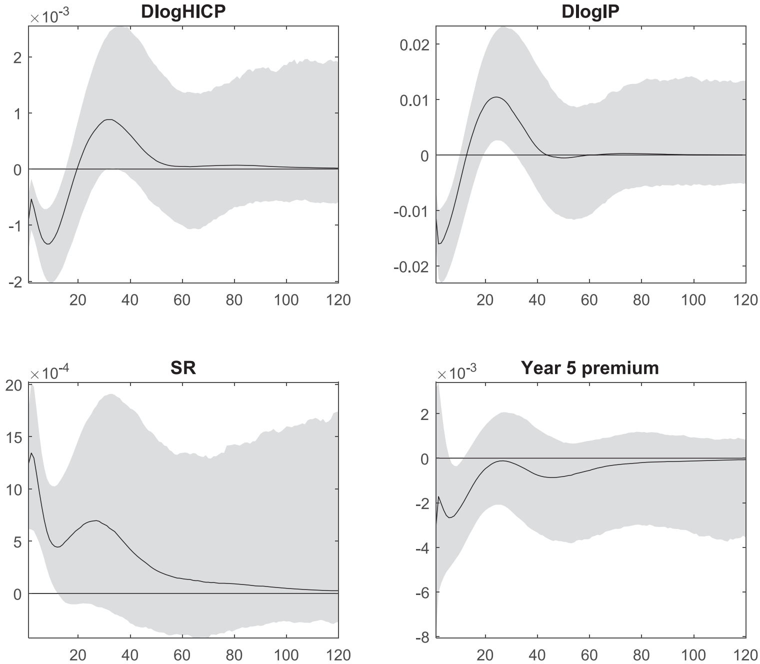
Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

premia. The analyzed time period is also limited, and the analysis has focused on the euro area. To show that these possible doubts are not justified, I run the following additional exercise.

Damodaran provides a data set that includes equity premium estimate for the United States from 1961 to 2019 at the annual level.[28] The method used for the calculation of implied premium is described by Damodaran (2020). The method is very similar to the approach where I apply Equation (2). The premium can be

[28]http://pages.stern.nyu.edu/∼adamodar/.

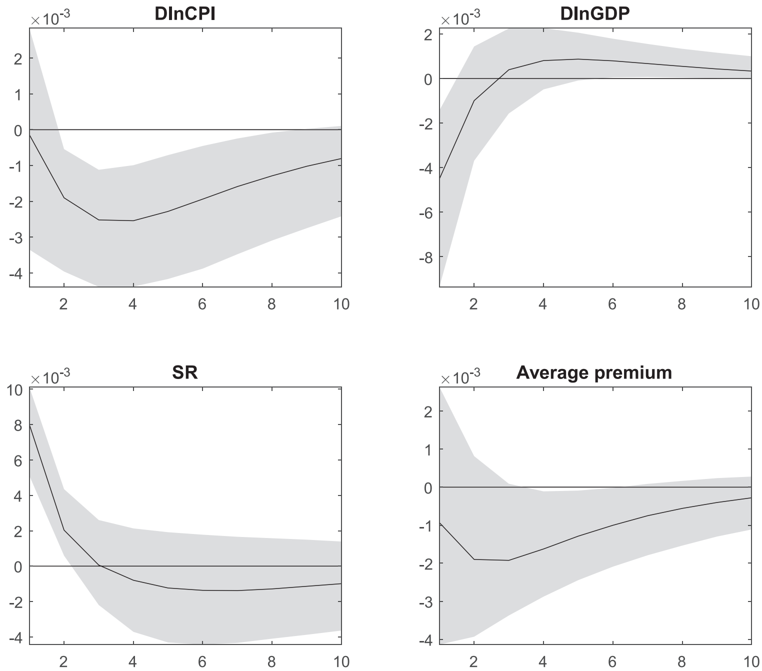
Figure 7. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Year 5 Premium Implied by Equation (3) and Dividend Futures



Note: Sign restrictions are imposed to DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

interpreted as an expected long-run average premium. I include this variable in a VAR model together with the measure of monetary policy and the changes in logarithms of CPI and GDP. As a measure of monetary policy, I use the shadow rate constructed by Krippner (2015). In practice, this variable is equal to the effective federal funds rate most of the time. The model includes one lag and a constant. I identify the monetary policy shock using sign restrictions. I assume that a positive monetary policy shock has a negative effect on CPI and GDP one period after the shock. The sign restriction to the shadow rate is imposed only for the first period.

Figure 8. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium by Damodaran (2020)



Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the first period. The shaded area represents the 68 percent confidence interval. The number of lags is one. The data are from 1961 to 2019 and from the United States.

The results are shown in Figure 8. The impulse response function of the premium is very similar to the impulse response function in Figure 5. The response is negative, and it lasts about a decade.

5.2 Results Are in Line with Bernanke and Kuttner (2005)

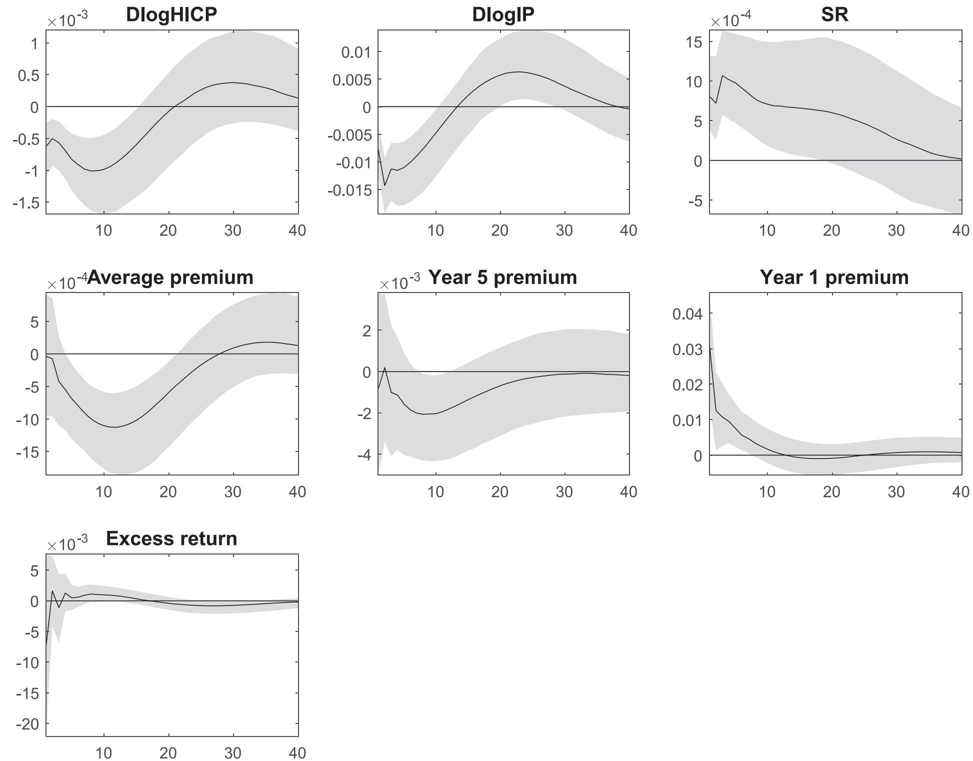
The results may seem strange given the evidence by Bernanke and Kuttner (2005). After all, the results are in line with the previous literature. This subsection aims at clarifying this issue.

The literature has not assessed the effect of monetary policy on discounting of dividends at long horizons. Instead, it has analyzed the effects on (rather short-run) excess returns of stocks over the risk-free returns. In the paper by Bernanke and Kuttner (2005, p. 1250, Figure 6) the effect on excess return is assessed about two years, meaning that the results by Bernanke and Kuttner (2005) should be compared to the impulse response functions of short-horizon implied premia rather than long-horizon premia. The immediate response of the year 1 premium is sharp and positive, meaning that the market price of dividends declines relative to the dividend expectations. The market price of dividends remains low relative to the dividend expectations about 12 months. In Bernanke and Kuttner (2005), the immediate excess return of stocks after a positive monetary policy shock is strongly negative (as in this paper, market price declines). Then the response remains positive about two years. This is consistent with the response of year 1 premium in this paper: the ex ante one-year-ahead excess return remains positive about 12 months.

The relationship between the results of this paper and the results of Bernanke and Kuttner (2005) are illustrated in Figure 9. The figure shows the impulse responses to monetary policy shock in a model that is otherwise as the baseline VAR model but includes long-horizon average, year 5 and year 1 premia at the same time, and the realized excess return. The excess return is calculated by subtracting monthly risk-free return from the monthly return of stocks.[29] The identification of the model is as in the baseline VAR model. The impulse response functions of the implied premia are as in the earlier analysis of this paper. The effect on excess return is as in Bernanke and Kuttner (2005). It is also worth noticing that the sign of the response changes after about two years, which is in line with the results regarding the long-horizon implied premia.

[29]The monthly risk-free return is obtained by using the Nelson-Siegel model to OIS rates. The maturities of the OIS rates vary between three months and 30 years.

Figure 9. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model Where, in Addition to Three Different Premia, Realized Monthly Excess Return Is Included



Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

5.3 Some Tentative Analysis and Discussion about the Mechanism

So far, the paper has not said much about the underlying mechanism that could explain the results. This subsection considers some potential explanations briefly. At the same time, it hopefully raises some new ideas for the future research.

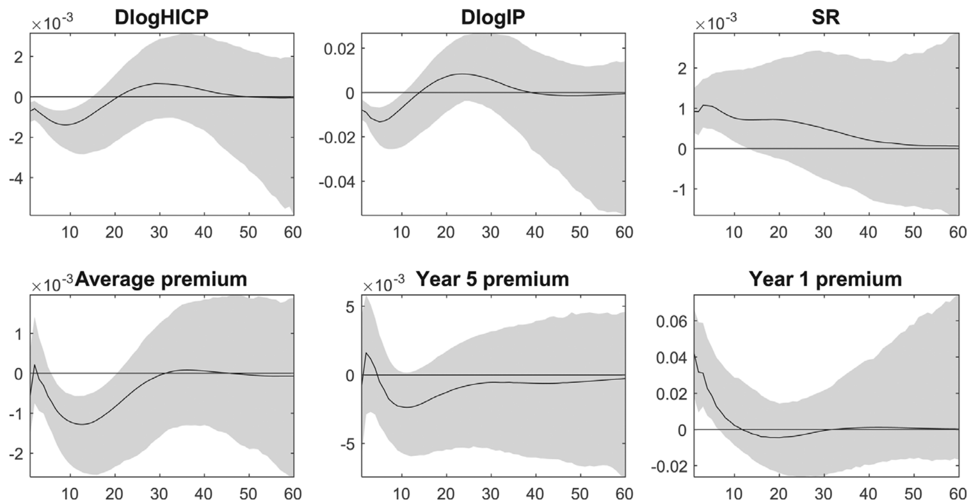
As mentioned earlier, the papers by Caballero and Farhi (2013, 2018) suggest that asset purchases of safe long-term government bonds may raise stock market risk premia. It matters whether the central bank buys risky or less risky assets. This mechanism receives some support, as the effects of surprise in the spread between Italian and German government bond yields and the surprise in long-term risk-free rate seem to differ (see Appendix E).

Another potential channel through which contractionary monetary policy could lower the long-horizon risk premia is expected inflation or inflation risk premium (Modigliani and Cohn 1979; Schotman and Schweitzer 2000). If this explanation was true, then it would seem natural that survey-based inflation expectations and the yields of inflation swaps would decline after a contractionary monetary policy shock. Appendix F augments the model with inflation expectations. The results do not support inflation-based explanations.

A third explanation considered here is the rationality of analysts' dividend forecasts. Easton and Sommers (2007) provide some evidence about the upward bias in the analysts' forecasts and show how this bias affects to their implied risk premium. Another article that provides evidence about the irrationality of survey-based expectations is by Greenwood and Shleifer (2014). Appendix G shows that these mechanisms may exist, but they seem to play an economically insignificant role.

Another issue related to the analysts' forecasts is that equity analysts do not necessarily update their forecasts every month and the forecasts used in this paper may not reflect the analysts' actual expectations. To consider this issue, in the model of Figure 10, it is assumed that the analysts' expectations represent the expectations of the previous month. The lag of one month is chosen because most

Figure 10. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model That Includes Three Different Premia



Note: The analysts' dividend expectations are assumed to be updated with a lag of one month. Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

dividend forecasts seem to be updated at least every second month. This does not seem to affect the results.[30]

The issues raised in this subsection are just examples about potential mechanisms that could explain the interesting responses of implied premia. There may, of course, be many other explanations for the results. One mechanism that was mentioned earlier, but has not been assessed in this subsection, is the one by Galí (2014). Another potential explanation, not addressed here, could be related to the results by Liu, Mian, and Sufi (2022). In their paper they observe that low interest rates may have different implications for different firms (market leaders and followers) due to strategic behavior. The Eurostoxx 50 index includes large companies only, which may affect the results. Hou et al. (2021a, 2021b) in turn show that the high expected profitability of firms is related to high expected returns. Monetary policy, as it affects the profitability of firms, may have pricing implications through this channel. It is likely that the effect of monetary policy on the term structure of risk premia is not the same for all the companies given the evidence by, for example, Maio (2014). Therefore, it could be an interesting idea to apply the methodology of this article to individual stocks.

6. Conclusions

Interest rates have declined considerably since the global financial crisis, yet the expected average stock market return has remained quite stable at around 9 percent. This implies that expected average stock market premium has increased remarkably. This rise is mainly driven by the premia over a discounting horizon of four years.

[30]Appendix D shows that the results remain the same even though one uses the permanent component of Beveridge-Nelson (1981) decomposition as a measure of true dividend expectations. This method is proposed by Jokivuolle (1995) to measure the value of true stock index that is not directly observable due to infrequent trading of stocks. In this paper, the “infrequent trades” are infrequent dividend forecast updates. One idea for the future research would be to use “flash estimates” of dividend forecast. Because analysts do not update their forecasts at the same time, one could use only the forecasts that have been updated during the past month. The Institutional Brokers’ Estimate System (IBES) provides these kind of flash estimates.

These results may seem unintuitive, as the prices of stocks have risen and ratios like price-to-earnings have been historically high. However, high price-to-earnings ratios or low dividend yields do not necessarily mean that stocks are expensive, because the value of a stock is the present value of its *future dividends*.

When it comes to the role of monetary policy, the results show that monetary policy easing decreases short-horizon required premia but increases longer-horizon premia. The effect on expected average premium is positive, i.e., expansionary monetary policy makes the prices of stocks cheap in comparison with the expected dividend stream and risk-free rates.

These results show that the conventional wisdom that monetary policy easing makes stock market valuation high is likely to be false. They underline the fact that the effect of monetary policy on stock market valuation is a puzzle that has not been solved yet.

One potential reason for the results is the channel proposed by Caballero and Farhi (2013, 2018) that was discussed in Section 2.3. However, the results seem to hold for conventional and unconventional policies, while the mechanism by Caballero and Farhi (2013, 2018) is related to a certain type of unconventional policies. These facts suggest that there are also some other mechanisms that explain the results. These mechanisms may be related to rational asset price bubbles as discussed by Galí (2014) and Galí and Gambetti (2015). Another explanation could be the fact that inflation seems to affect stock market risk premia even though the results of this paper do not support this idea (e.g., Modigliani and Cohn 1979; Schotman and Schweitzer 2000). The results may also be related to the empirical observation by Binsbergen et al. (2013) that the slope of equity risk premium curve varies over the business cycle. Analysts' potentially biased dividend forecasts may also be one part of the explanation. These open questions are left for the future research.

Appendix A

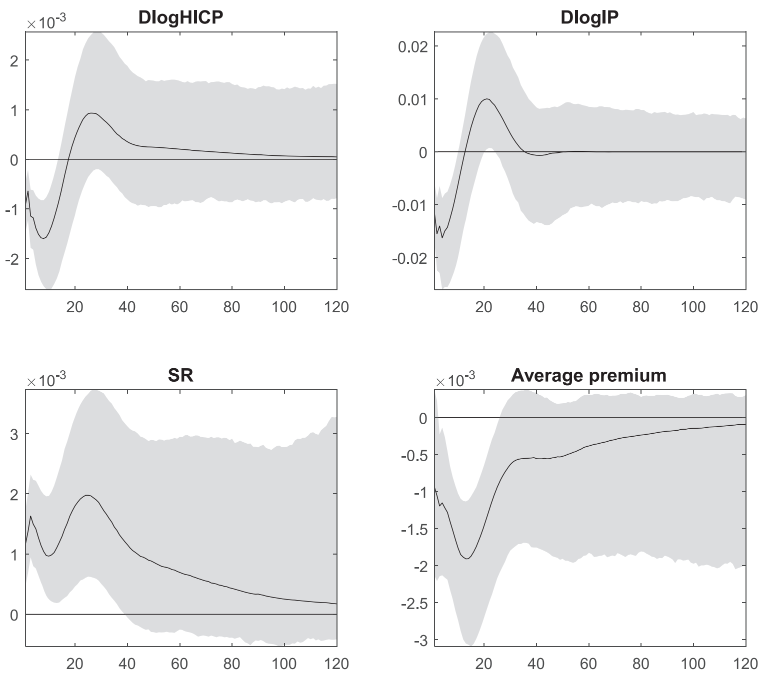
This section shows a set of robustness checks for the baseline VAR model. The models in this section mainly consider long-run average premium. Similar robustness tests regarding the short-horizon premia are shown in the online appendix.

Figure A.1 shows the results after increasing the number of lags to four. Otherwise, the model is as in the baseline VAR analysis. The results remain almost the same.

Figure A.2 shows the results when HICP and industrial production are in log-levels. The signs restrictions are still imposed for periods 1 to 9. The results are robust to using levels instead of differences.

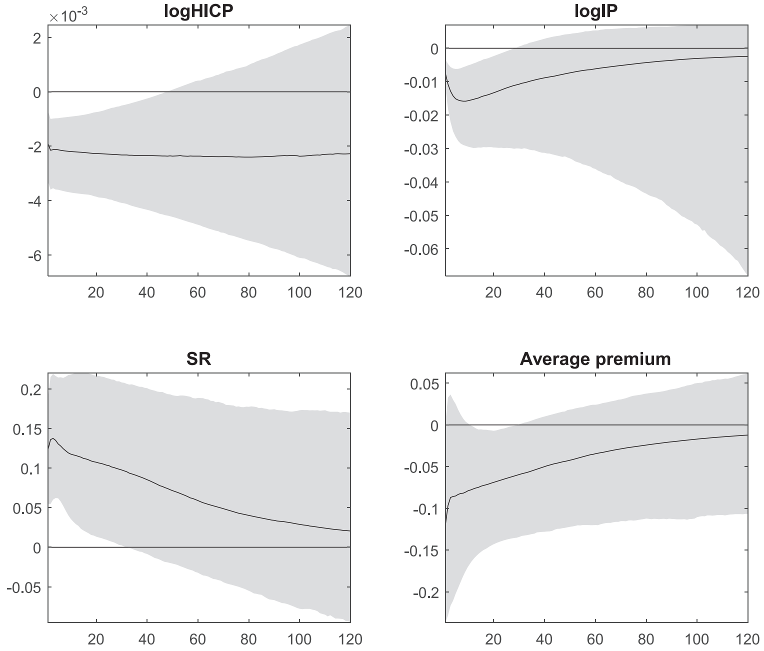
There are many other shadow rate estimates than the one proposed by Kortela (2016). In Figures A.3 and A.4, the shadow rates

Figure A.1. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is four.

Figure A.2. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



Note: Sign restrictions are imposed on logIP, logHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is 12.

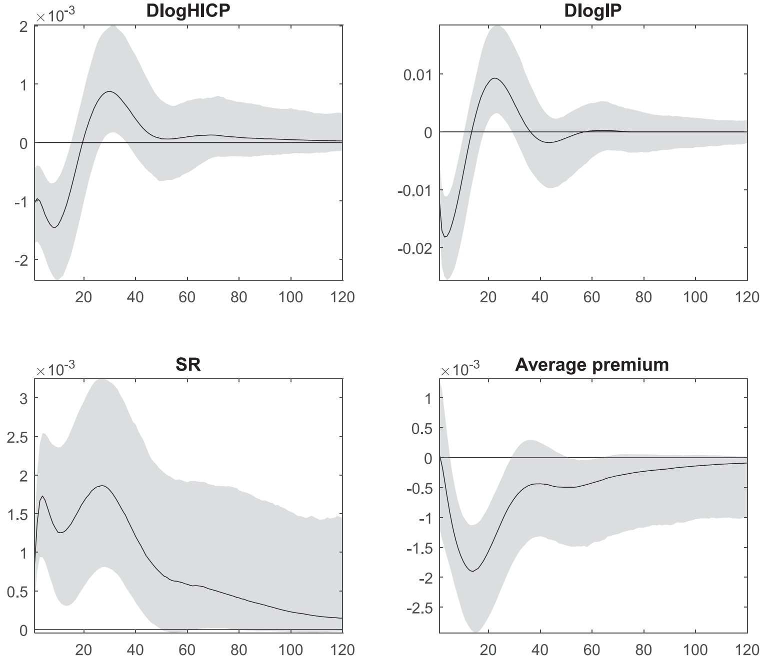
by Krippner (2015) and Wu and Xia (2016) are used. The results remain about the same.

Figure A.5 shows that the results do not change even though one imposes the sign restriction only for the first three periods. The results also remain the same even though one uses recursive identification instead of sign restrictions (Figures A.6 and A.7).

One could also ask, What happens if I include multiple premia in the model? The results remain the same, as shown in Figure A.8.

There are multiple empirical papers documenting that stock prices react positively to monetary policy easing. Assuming that this

Figure A.3. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)

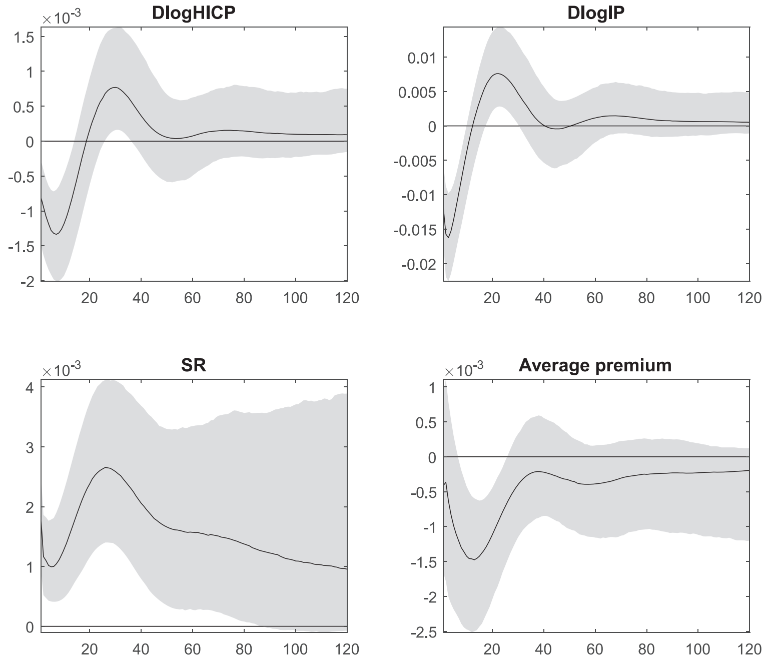


Note: The shadow rate by Kortela (2016) is replaced by the shadow rate by Krippner (2015). Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

really is the case, Figure A.9 reports the results when the change in log($Eurostoxx$ 50) is included to the model and assumed to respond negatively the first two periods after the shock. The result regarding the effect on long-run risk premium is unaffected.

Finally, there is some evidence that the effects of monetary policy may vary over time (e.g., Laine 2020). To study this issue, I conduct a simple rolling-window analysis, in which the model includes only the shadow rate and the premium implied by Equation (2) in this

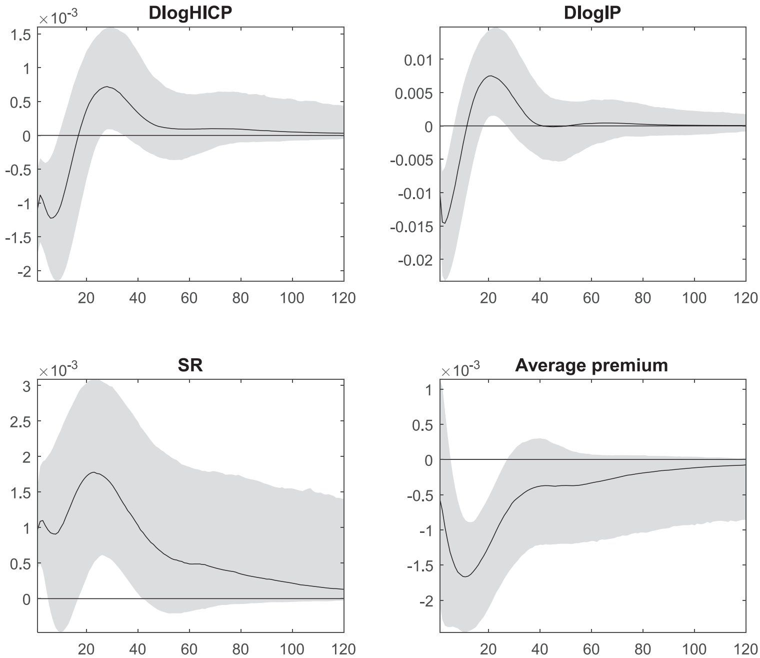
Figure A.4. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



Note: The shadow rate by Kortela (2016) is replaced by the shadow rate by Wu and Xia (2016). Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

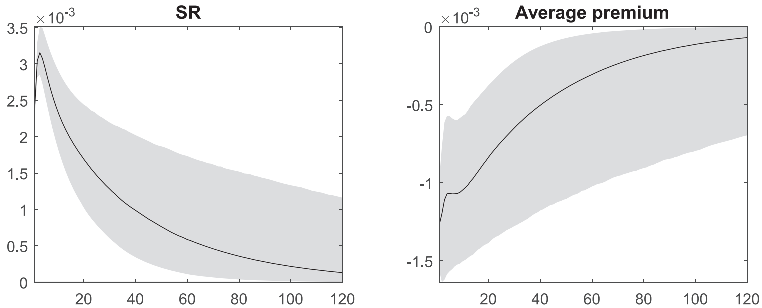
order. Monetary policy shock is identified recursively. The length of the window is 120 months, and the window is moved 6 months at a time. The first estimation window ends in July 2016. The results are shown in Figure A.10. The effect on long-run average expected premium seems not to vary over time.

Figure A.5. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



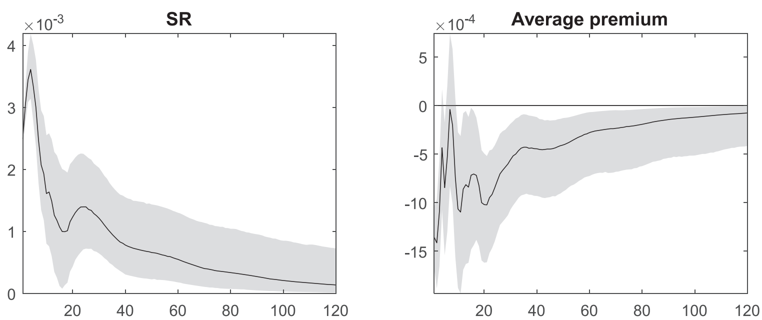
Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR. The sign restrictions are now set to hold only the first three periods. The shaded area represents the 68 percent confidence interval. The number of lags is two.

Figure A.6. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



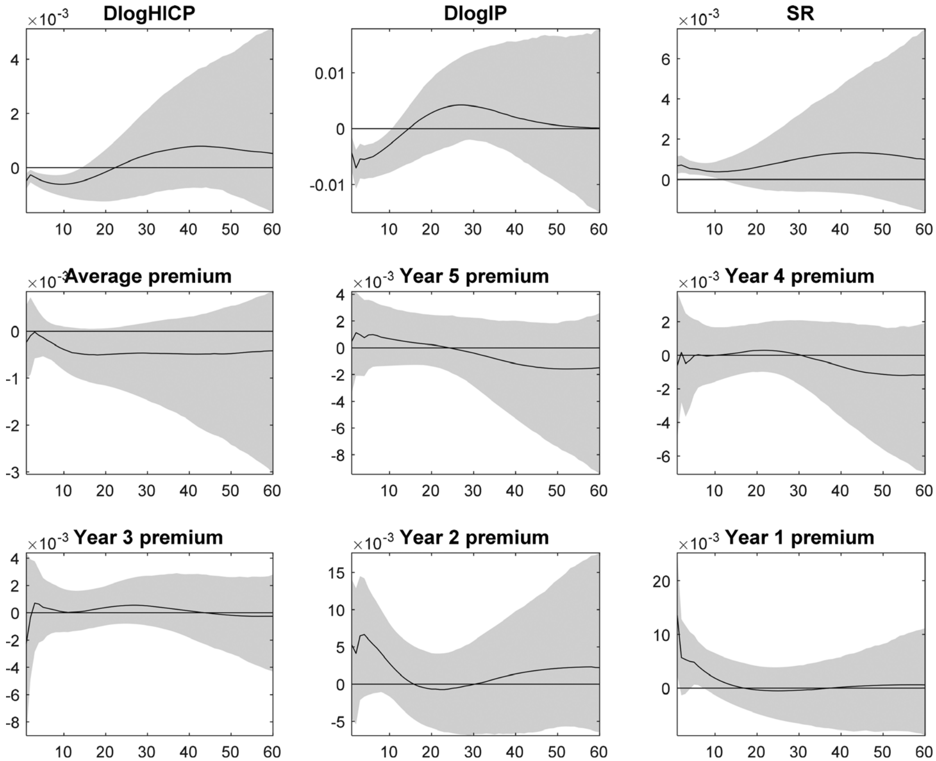
Note: The structural model is identified recursively. Average premium is ordered after the shadow rate. The shaded area represents the 68 percent confidence interval. The model includes two lags.

Figure A.7. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



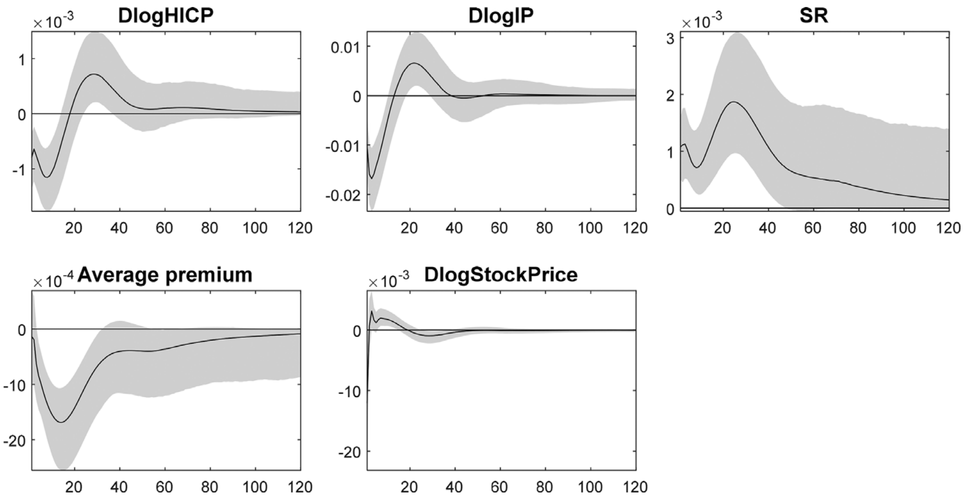
Note: The structural model is identified recursively. Average premium is ordered after the shadow rate. The shaded area represents the 68 percent confidence interval. The model includes 12 lags.

Figure A.8. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premia Are the Long-Run Average Expected Premium Implied by Equation (2) and Year 1, 2, 3, 4, and 5 Premia Implied by Equation (3)



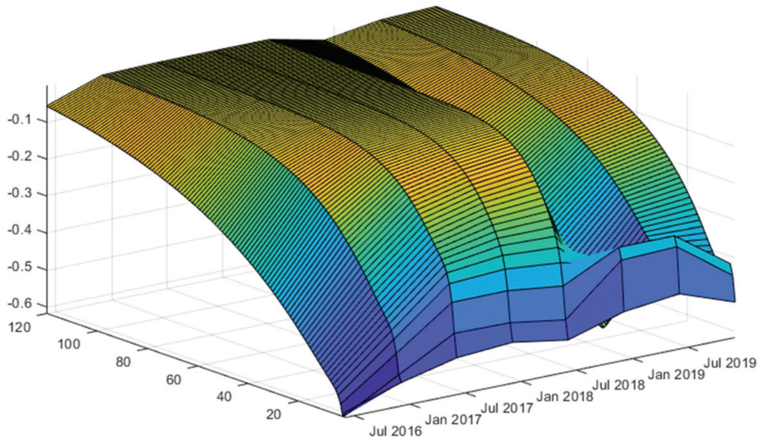
Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

Figure A.9. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model in Which the Premium Is the Long-Run Average Expected Premium Implied by Equation (2)



Note: The change in log(Eurostoxx 50) is included in the model. Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9 and on DlogStockPrice for the periods 1–2. The shaded area represents the 68 percent confidence interval. The number of lags is two.

Figure A.10. Time Variation of the Impulse Response Functions of the Long-Run Average Expected Premium Implied by Equation (2) to One-Standard-Deviation Positive Shock to the Shadow Rate



Note: The model includes SR and the premium in this order. The shock is identified recursively, and the size of the shock is normalized to 1 percent. The model has two lags. The dates on the axis tell the last period included in the estimation window. (For figures in color, see the online version of the paper at http://www.ijcb.org.)

Appendix B

Figure B.1 shows the development of risk premium and rate of return, when the long-run dividend growth rate, g, is assumed to have declined linearly from 4.5 percent to 0.5 percent during the period. Even in this case the risk premium seems to exhibit a small upward trend. It does not seem very likely that the long-run expected growth rate would have declined more than 4 percentage points. Figure B.2 shows the same development, if it was assumed that g is equal to 1 percent plus the average of (time-varying) rate of 10-year inflation swap and long-run expected inflation from the Survey of Professional Forecasters (SPF). Using inflation expectation as a proxy for the long-run nominal growth rate does not change the conclusions.

Figure B.1. Solved Expected Rate of Return and Expected Premium, When *g* Is Assumed to Have Declined from 4.5 Percent to 0.5 Percent

Note: The variables are solved applying Equation (2) to Eurostoxx 50 stock market index and analysts' consensus forecasts in the period from June 2006 to April 2020.

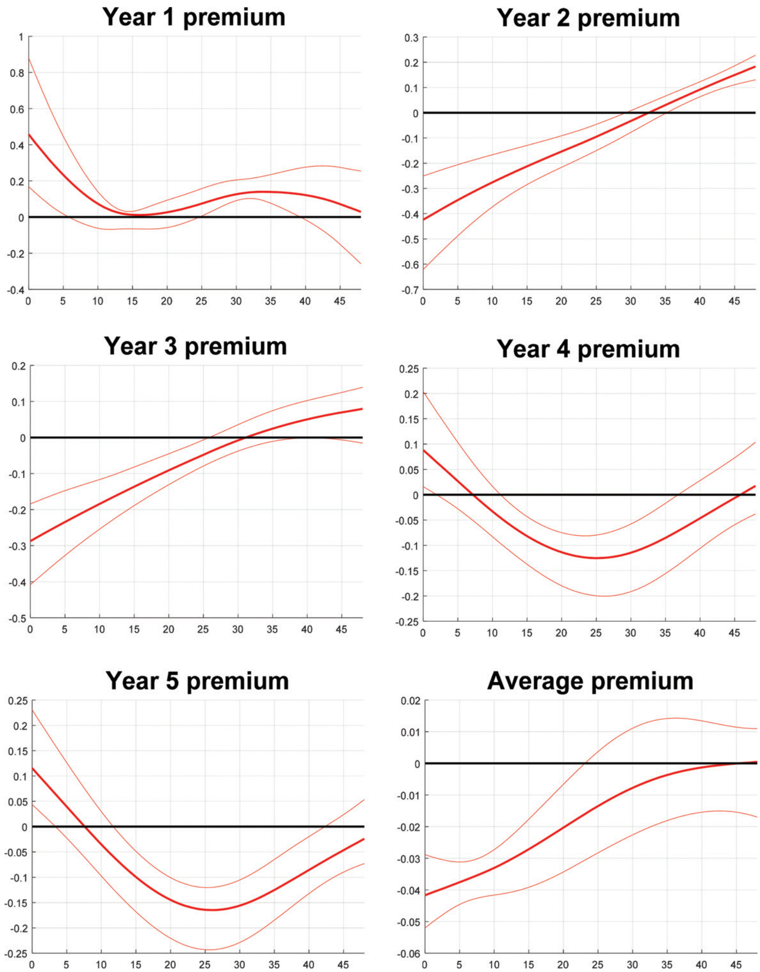
Figure B.2. Solved Expected Rate of Return and Expected Premium, When *g* Is Assumed to Equal 1 Percent + (the rate of 10-year inflation swap + long-run inflation expectation from SPF)/2

Note: The variables are solved applying Equation (2) to Eurostoxx 50 stock market index and analysts' consensus forecasts in the period from June 2006 to April 2020.

Appendix C

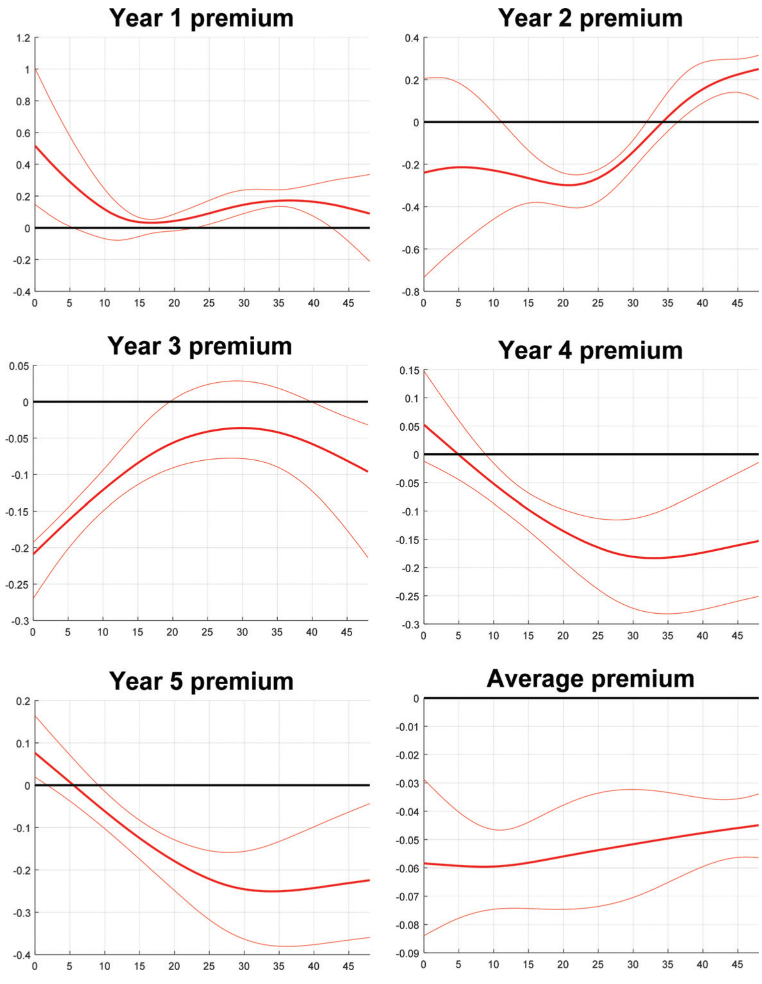
Figure C.1 uses three-month surprise instead of the average surprise. Figure C.2 shows the results when the number of lags is increased to four. The results are hardly affected.

Figure C.1. Local-Projection-Based Impulse Response Function of the Year 1, 2, 3, 4, and 5 Premia Implied by Equation (3) and the Long-Run Average Expected Premium Implied by Equation (2)



Note: The number of lags in the model is three. Inflation and the growth rate of industrial production are used as control variables. Three-month surprise is used as a shock. The confidence band is 68 percent. The impulse response functions and their Newey-West-based confidence bands are estimated as in Barnichon and Brownlees (2019).

Figure C.2. Local-Projection-Based Impulse Response Function of the Year 1, 2, 3, 4, and 5 Premia Implied by Equation (3) and the Long-Run Average Expected Premium Implied by Equation (2)



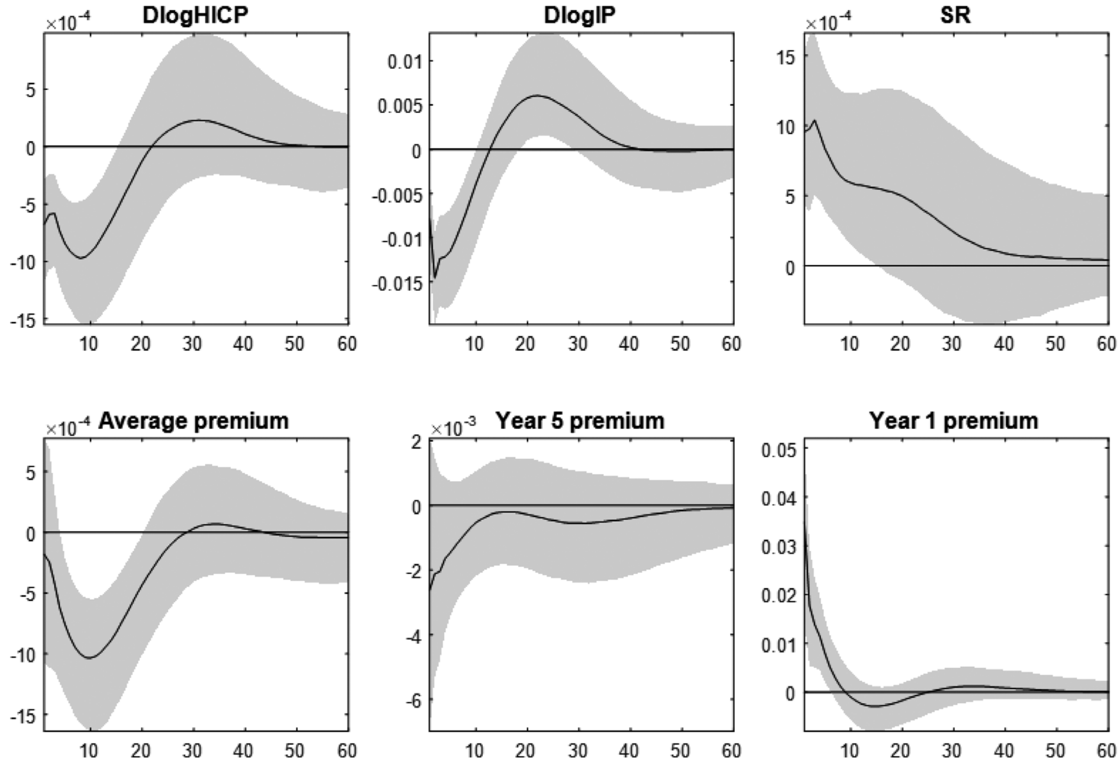
Note: The number of lags in the model is four. Inflation and the growth rate of industrial production are used as control variables. The confidence band is 68 percent. The impulse response functions and their Newey-West-based confidence bands are estimated as in Barnichon and Brownlees (2019).

Appendix D

Jokivuolle (1995) shows that the permanent component of Beveridge-Nelson (1981) decomposition can be used to measure the true value of stock index that is not directly observable due to infrequent trading of stocks. I apply this method to analysts' dividend expectations: the "infrequent trades" are in my case infrequent dividend forecast updates. The method of Jokivuolle (1995) assumes that the log of true index follows a random walk with drift. The possible autocorrelation in the observed series should then reflect infrequent trading, and Beveridge-Nelson (1981) decomposition corrects this. Using the method of Jokivuolle (1995) is a conservative approach. For example, Coibion and Gorodnichenko (2015) and Bouchaud et al. (2019) provide evidence that the expectations might be sticky. Therefore, the method of Jokivuolle (1995) probably overcorrects the expectations.

Figure D.1 shows the impulse response functions when the analysts' dividend forecasts are corrected using the method of Jokivuolle (1995). The number of lags assumed in the Beveridge-Nelson (1981) decomposition is 12. The method affects the implied risk premia, but the impulse response functions remain about the same.

Figure D.1. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model That Includes Three Different Premia

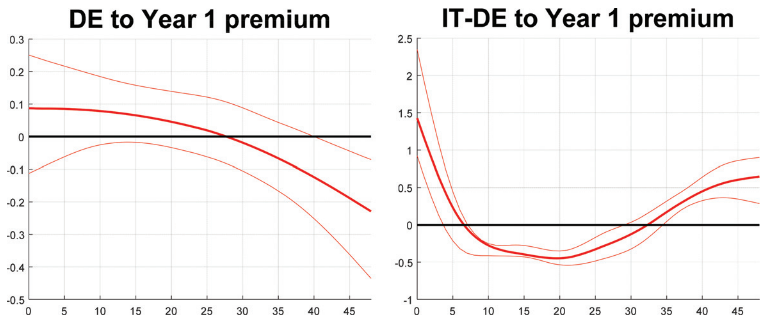


Note: The analysts' dividend expectations are corrected using the method of Jokivuolle (1995). Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

Appendix E

Figure E.1 shows the local projection impulse responses of the year 1 premium to rate surprises in (i) the 10-year yield of Germany (DE) and (ii) the spread between the 10-year yields of Italy and Germany (IT-DE spread). The bond of Germany can be considered as a risk-free or negative-beta asset. The government bond of Italy, instead, is a relatively risky asset. Surprises in the German yield are probably correlated to the announcements of policies related to asset purchases aimed at safe assets. Surprises in the spread are probably correlated to the announcements of asset purchases aimed at riskier asset. The immediate reaction to the surprise in the German yield is positive but economically rather small compared with the response after the surprise in IT-DE spread. The positive response is also within the confidence bands, unlike in the case of IT-DE spread. This simple analysis suggests that stock market risk premia respond differently to different kind of asset purchases. In light of these results, it might be interesting to assess the mechanism of Caballero and Farhi (2013, 2018) more carefully in future research. For example, the rate surprises are correlated with each other and

Figure E.1. Local-Projection-Based Impulse Response Function of the Year 1 Premium Implied by Equation (3)



Note: The changes in the German 10-year government bond yield and the spread between 10-year Italian government bond yield and the German one around the ECB's decisions are used as proxies for monetary policy shocks. The number of lags in the model is three. The confidence band is 68 percent. The impulse response functions and their Newey-West-based confidence bands are estimated as in Barnichon and Brownlees (2019).

announcements of different asset purchase programs affect multiple yields and spreads. In the future research, it would be interesting to disentangle these different policies in a more careful way.[31]

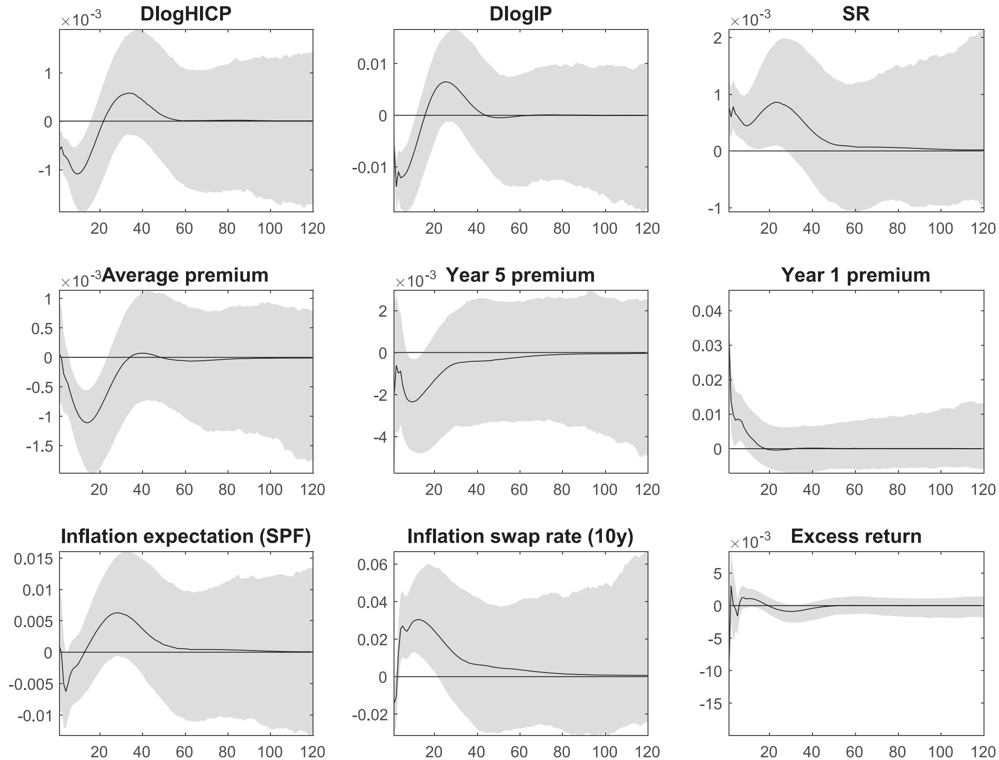
Appendix F

Figure F.1 shows the impulse response functions of the model that has been augmented with the rate of 10-year inflation swap and long-term inflation expectation (from the Survey of Professional Forecasters, SPF). The excess return of stocks is also added. The identification is otherwise as in the baseline VAR model, but the immediate reactions of the inflation swap and the excess return are restricted to negative to further improve the identification.

The results do not support the idea that monetary policy easing would raise the long-horizon premia through the higher inflation risks. At least the identified policy shock does not seem to move survey- and market-based expectations to the right direction. Even though the immediate reaction of the inflation swap is restricted to negative, the data seem to think otherwise: the sign of the response changes rapidly.

[31] One way to disentangle different monetary policies has been proposed recently by Kortela and Nelimarkka (2020). Nelimarkka and Laine (2021) use this methodological framework to assess the effectiveness of different monetary policy measures during the COVID-19 pandemic.

Figure F.1. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model, Which Has Been Augmented by Survey-Based Long-Term Inflation Expectation (SPF), 10-Year Inflation Swap Rate, and the Monthly Excess Return of Stocks



Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9, and on the inflation swap rate and on the excess return for the first period. The shaded area represents the 68 percent confidence interval. The number of lags is two.

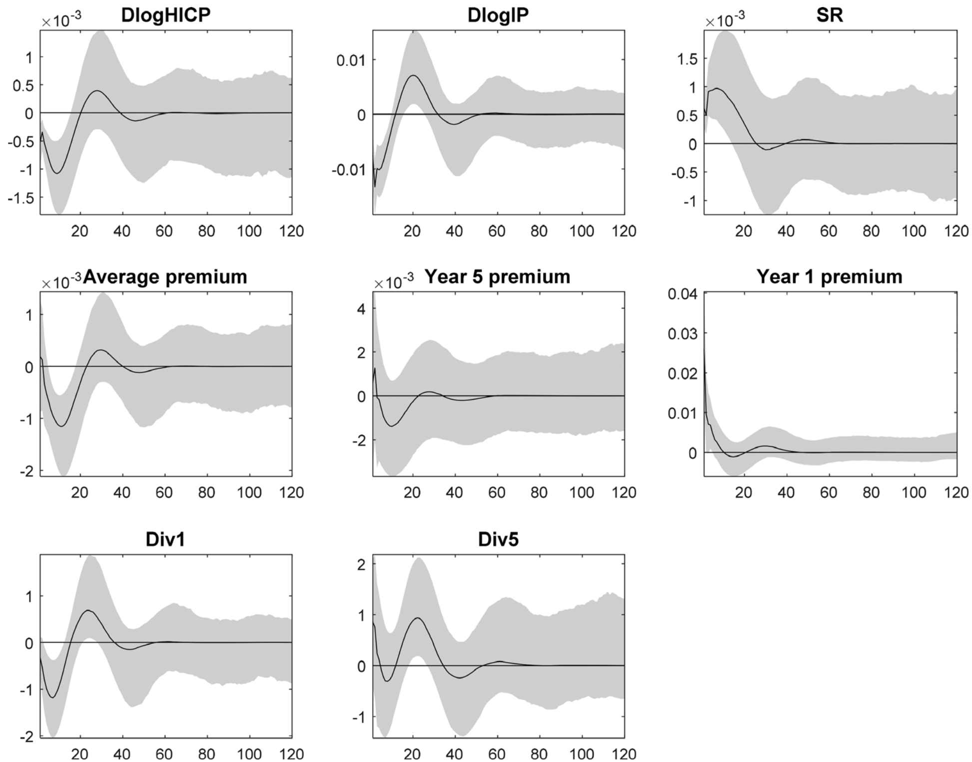
Appendix G

Figure G.1 shows the impulse response functions of the model that is augmented with the analysts' dividend forecasts one year ahead (Div1) and five years ahead (Div5). Div1 declines after contractionary monetary policy, but Div5 stays about the same or even rises. The reaction of Div5 may seem strange given that contractionary monetary policy can be expected to lower the profits of firms. To further analyze whether this reflects some systematic error in the analysts' expectations, I consider the forecast errors made by analysts.

Figure G.2 shows the histogram of the analysts' forecast errors at the horizon of five years. The error has been calculated as a log-difference between the expected dividend and the realized dividend. The distribution is skewed to the right, and the analysts have been on average about 10 percent too optimistic. The largest forecast errors happened during the financial crisis and the years 2015–16.

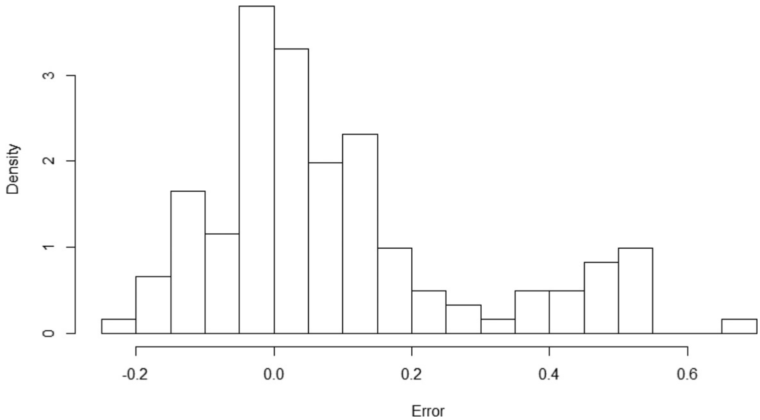
The key question is whether the expectation errors are caused by monetary policy shocks. If this was the case, one could say that monetary policy causes positive or negative "bubbles in dividend expectations." Figure G.3 shows the local projection impulse response that is followed by the surprise in the average OIS rate. The response is positive, suggesting that contractionary monetary policy makes analysts too optimistic. Therefore, it is possible that some systematic errors made by analysts explain the results of this paper partly. However, it should be noted that the response in Figure G.3 is not economically significant: a 1 percentage point rate surprise causes only about 1 percent prediction error in five-years-ahead dividend forecast.

Figure G.1. Impulse Response Functions to a One-Standard-Deviation Positive Shock to the Shadow Rate in the Model, Which Has Been Augmented by One-Year-Ahead and Five-Years-Ahead Dividend Forecasts



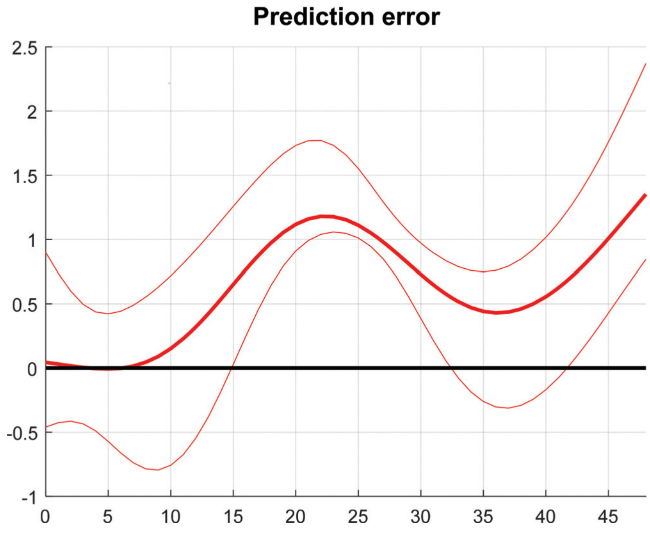
Note: Sign restrictions are imposed on DlogIP, DlogHICP, and SR for the periods 1–9. The shaded area represents the 68 percent confidence interval. The number of lags is two.

Figure G.2. Histogram of Five-Years-Ahead Forecast Errors Made by Analysts



Note: The error is defined as log(dividend forecast)-log(realized dividends).

Figure G.3. Local-Projection-Based Impulse Response Function of the Analysts' Five-Years-Ahead Forecast Error



Note: The number of lags in the model is three. The confidence band is 68 percent. The impulse response function and its Newey-West-based confidence bands are estimated as in Barnichon and Brownlees (2019).

References

Altavilla, C., L. Brugnolini, R. S. Gürkaynak, R. Motto, and G. Ragusa. 2019. "Measuring Euro Area Monetary Policy." *Journal of Monetary Economics* 108 (December): 162–79.

Barnichon, R., and C. Brownlees. 2019. "Impulse Response Estimation by Smooth Local Projections." *Review of Economics and Statistics* 101 (3): 522–30.

Berg, T. 2010. "The Term Structure of Risk Premia: New Evidence from the Financial Crisis." Working Paper No. 1165, European Central Bank.

Berg, T., and C. Kaserer. 2013. "Extracting the Equity Premium from CDS Spreads." *Journal of Derivatives* 21 (1): 8–26.

Bernanke, B. S., J. Boivin, and P. Eliasz. 2005. "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics* 120 (1): 387–422.

Bernanke, B. S., and K. N. Kuttner. 2005. "What Explains the Stock Market's Reaction to Federal Reserve Policy? *Journal of Finance* 60 (3): 1221–57.

Beveridge, S., and C. R. Nelson. 1981. "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the 'Business Cycle'." *Journal of Monetary Economics* 7 (2): 151–74.

Binsbergen, J., M. Brandt, and R. Koijen. 2012. "On the Timing and Pricing of Dividends." *American Economic Review* 102 (4): 1596–1618.

Binsbergen, J., W. Hueskes, R. Koijen, and E. Vrugt. 2013. "Equity Yields." *Journal of Financial Economics* 110 (3): 503–19.

Binsbergen, J. H., and R. S. Koijen. 2017. "The Term Structure of Returns: Facts and Theory." *Journal of Financial Economics* 124 (1): 1–21.

Black, F. 1995. "Interest Rates as Options." *Journal of Finance* 50 (5): 1371–76.

Borio, C., and H. Zhu. 2012. "Capital Regulation, Risk-taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial Stability* 8 (4): 236–51.

Bouchaud, J. P., P. Krueger, A. Landier, and D. Thesmar. 2019. "Sticky Expectations and the Profitability Anomaly." *Journal of Finance* 74 (2): 639–74.

Caballero, R. J., and E. Farhi. 2013. "A Model of the Safe Asset Mechanism (SAM): Safety Traps and Economic Policy." Working Paper No. 18737, National Bureau of Economic Research.

———. 2018. "The Safety Trap." *Review of Economic Studies* 85 (1): 223–74.

Claus, J., and J. Thomas. 2001. "Equity Premia as Low as Three Percent? Evidence from Analysts' Earnings Forecasts for Domestic and International Stock Markets." *Journal of Finance* 56 (5): 1629–66.

Coibion, O., and Y. Gorodnichenko. 2015. "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts." *American Economic Review* 105 (8): 2644–78.

Damodaran, A. 2020. *Equity Risk Premiums: Determinants, Estimation and Implications—The 2020 Edition*. NYU Stern School of Business.

Easton, P. D., and G. A. Sommers. 2007. "Effect of Analysts' Optimism on Estimates of the Expected Rate of Return Implied by Earnings Forecasts." *Journal of Accounting Research* 45 (5): 983–1015.

Fama, E. F., and K. R. French. 2015. "A Five-Factor Asset Pricing Model." *Journal of Financial Economics* 116 (1): 1–22.

Ferroni, F., and F. Canova. 2020. "A Hitchhiker's Guide to Empirical Macro Models." Working Paper.

Galí, J. 2014. "Monetary Policy and Rational Asset Price Bubbles." *American Economic Review* 104 (3): 721–52.

Galí, J., and L. Gambetti. 2015. "The Effects of Monetary Policy on Stock Market Bubbles: Some Evidence." *American Economic Journal: Macroeconomics* 7 (1): 233–57.

Gebhardt, W. R., C. M. Lee, and B. Swaminathan. 2001. "Toward an Implied Cost of Capital." *Journal of Accounting Research* 39 (1): 135–76.

Gormsen, N. J., and R. S. Koijen. 2020. "Coronavirus: Impact on Stock Prices and Growth Expectations." *Review of Asset Pricing Studies* 10 (4): 574–97.

Greenwood, R., and A. Shleifer. 2014. "Expectations of Returns and Expected Returns." *Review of Financial Studies* 27 (3): 714–46.

Gust, C., and D. López-Salido. 2014. "Monetary Policy and the Cyclicality of Risk." *Journal of Monetary Economics* 62 (March): 59–75.

Hou, K., H. Mo, C. Xue, and L. Zhang. 2021a. "An Augmented q-factor Model with Expected Growth." *Review of Finance* 25 (1): 1–41.

———. 2021b. "The Economics of Security Analysis." Unpublished Manuscript.

Jokivuolle, E. 1995. "Measuring True Stock Index Value in the Presence of Infrequent Trading." *Journal of Financial and Quantitative Analysis* 30 (3): 455–64.

Kortela, T. 2016. "A Shadow Rate Model with Time-Varying Lower Bound of Interest Rates." Research Discussion Paper No. 19/2016, Bank of Finland.

Kortela, T., and J. Nelimarkka. 2020. "The Effects of Conventional and Unconventional Monetary Policy: Identification through the Yield Curve." Research Discussion Paper No. 3/2020, Bank of Finland.

Krippner, L. 2015. *Zero Lower Bound Term Structure Modeling: A Practitioner's Guide*. Springer.

Laine, O.-M. 2020. "The Effect of the ECB's Conventional Monetary Policy on the Real Economy: FAVAR-Approach." *Empirical Economics* 59 (6): 2899–2924.

Lamponi, D., and D. Latto. 2017. "The Life Cycle of Dividend Futures and the Dividend Risk Premium: A Practitioner's Perspective." *Journal of Wealth Management* 20 (2): 67–75.

Liu, E., A. Mian, and A. Sufi. 2022. "Low Interest Rates, Market Power, and Productivity Growth." *Econometrica* 90 (1): 193–221.

Maio, P. 2014. "Another Look at the Stock Return Response to Monetary Policy Actions." *Review of Finance* 18 (1): 321–71.

Modigliani, F., and R. A. Cohn. 1979. "Inflation, Rational Valuation and the Market." *Financial Analysts Journal* 35 (2): 24–44.

Nelimarkka, J., and O.-M. Laine. 2021. "The Effects of the ECB's Pandemic-Related Monetary Policy Measures." BoF Economics Review No. 4/2021.

Patelis, A. D. 1997. "Stock Return Predictability and the Role of Monetary Policy." *Journal of Finance* 52 (5): 1951–72.

Rubio-Ramirez, J., D. F. Waggoner, and T. Zha. 2010. “Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference.” *Review of Economic Studies* 77 (2): 665–96.

Schotman, P. C., and M. Schweitzer. 2000. “Horizon Sensitivity of the Inflation Hedge of Stocks.” *Journal of Empirical Finance* 7 (3–4): 301–15.

Wilkens, S., and J. Wimschulte. 2010. “The Pricing of Dividend Futures in the European Market: A First Empirical Analysis.” *Journal of Derivatives and Hedge Funds* 16 (2): 136–43.

Williams, J. B. 1938. *The Theory of Investment Value.* Cambridge, MA: Harvard University Press.

Wu, J. C., and F. D. Xia. 2016. “Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.” *Journal of Money, Credit and Banking* 48 (2–3): 253–91.