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SNB Working Papers
8/2021

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SWISS NATIONAL BANK

Legal Issues

ISSN 1660-7716 (printed version)
ISSN 1660-7724 (online version)

Habits die hard: implications for bond and stock markets internationally*

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13 April 2021

Abstract

This paper assesses whether the global fall in inflation expectations together with increased fear of recession, the economic mechanism that drives asset prices in a model with consumption habits, help to explain the downward trajectory in nominal government bond yields and the stock price dynamics of six major economies from 1988 to 2019. We calibrate the habit model for each country separately. For most countries, focusing the calibrations on matching average ten-year bond yields allows one to generate artificial time series of bond yields and price-consumption ratios that follow the long-run time series patterns of their counterparts in the data.

JEL: G12, G15

KEYWORDS: consumption habit, return, risk premium, yields

*We are grateful to Jessica A. Wachter for sharing her Matlab code of the consumption habit model with us. We thank an anonymous referee of the SNB working paper series, Petra Gerlach, Oliver Gloede and participants of the SNB Brown Bag Seminar for helpful comments and suggestions. Any errors and omissions are our own. The views, opinions, findings, and conclusions or recommendations expressed in this paper are strictly those of the authors. They do not necessarily reflect the views of the Swiss National Bank. The Swiss National Bank does not take responsibility for any errors or omissions in, or for the correctness of, the information contained in this paper.

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1 Introduction

Yields on long-term government bonds of the major economies have declined since the 1990s. Even adjusting for inflation expectations, we observe that long-term bond yields (long-term real interest rates) have fallen in many countries (e.g., Borio et al., 2017).

The question why long-term government bond yields started declining in the 1990s and remained low since the global financial crisis 2008-2009 has sparked many research initiatives in recent years.[1] Potential explanations range from the diagnosis of growing shortages of safe assets, such as government bonds (e.g., Cabellero et al., 2017) that depress yields on these assets to the notion that low nominal yields on long-term bonds reflect the fall of estimates of the real equilibrium interest rate in developed economies (e.g., Holston et al., 2017) and a decline in equilibrium inflation (Bauer and Rudebusch, 2020).

Against this background, surprisingly little attention has been paid to the question of whether the different explanations of the dynamics of yields on long-term government bonds of the major economies are consistent with explanations of the behaviour of other asset prices, e.g., equity, in these countries.

This paper aims at filling this gap because existing studies of the joint behaviour of bond yields and equity prices focus on the US (Hasseltoft, 2012; Farhi and Gourio, 2018; Miller et al., 2020). However, the US is not necessarily representative for other economies. An economic mechanism that explains the downward trend in nominal government bond yields internationally should also help to understand international stock price dynamics. This is no mean task as illustrated in Figure (1). The upper panel of Fig-

[1] Jorda et al. (2019) show that such one-directional, long-run movements of government bond yields (prices) are not unusual in historical comparisons. However, Del Negro et al. (2019) argue that the past thirty years of falling and currently low real interest rates/real government bond yields reflect an underlying global trend that has not been observed before.

ure (1) depicts the ten-year US treasury yield and a time series of the US log price-dividend ratio in this paper's sample period. The lower panel of Figure (1) shows the Swiss government bond yield and the Swiss log price-dividend ratio during the same period. While the nominal bond yields of both countries clearly follow a downward trajectory, there are pronounced cross-country differences in the dynamics of the price-dividend ratios.

[Figure (1) about here]

We argue that an economic mechanism related to business cycle dynamics can rationalize the long-run dynamics of international bond yields and stock prices during the sample period from 1988 to 2019. We also argue that a business cycle mechanism could explain cross-country differences in the joint behaviour of nominal bond yields and stock prices.

Figure (2) illustrates why. It depicts the OECD composite leading indicators (CLI), which are interpretable as output gaps, for the six countries in our sample (Canada, Germany, Japan, Switzerland, United Kingdom and the United States). With the exception of the great recession 2008-2009, when the CLIs of all countries fell sharply simultaneously, we observe cross-country differences in the timing and the amplitude of the CLIs. With risk aversion varying over the business cycle, this observation could help us to explain cross-country differences in the dynamics of nominal bond prices and stock prices over time. Moreover, Figure (2) shows that for most countries in our sample, the sharp drop in economic activity during the great recession was followed by an expansion that did not fully offset the impact of the great recession. This observation highlights that the assumption of increasing risk aversion due to more adverse business cycle dynamics in the latter than in the former half of our sample period is based on macroeconomic facts.

[Figure (2) about here]

In addition, there is evidence highlighting that risk aversion increased substantially after the global financial crisis 2008-2009 (Guiso et al., 2018).

More generally, Malmendier and Nagel (2011) show that experiences of severe economic shocks, such as the great recession, negatively affect individuals' willingness to take financial risks for the rest of their lives.

If nominal government bonds provide a hedge in times of low marginal utility (recessions), then increased risk aversion due to severe recessions, such as the one due to the global financial crisis, could explain the decline in nominal government bond yields internationally. US evidence shows that US treasury bonds provided such a hedge since 2000 (Campbell et al., 2019; Song, 2017); whether this evidence pertains to other countries' government bonds is an empirical question.

Our assessment of the question of whether lower inflation expectations together with fear of recession explain the joint dynamics of nominal government bond yields and stock prices internationally relies on the version of the Campbell and Cochrane (1999) consumption habit model by Wachter (2006). In this model, consumption relative to past consumption (habit) measures the investor's fear of recessions. In addition, the model allows the real risk-free rate of return to vary over time at the business cycle frequency. Consumption relative to habit (surplus consumption) and potential time variation in the risk-free rate drive real stock prices and real bond prices. Nominal bond prices additionally reflect inflation expectations, which are modelled as an exogenous process.

We use the extension of the Campbell and Cochrane (1999) habit model of Wachter (2006) as our theoretical benchmark because we view the economic mechanism of the model to be clear, simple and tightly linked to our hypothesis that business cycle dynamics could generate the joint dynamics of bond yields and stock prices internationally.[2] We do not claim that the habit model is the best benchmark model for assessing international bond and stock price dynamics per se. Cochrane (2017) emphasizes that the habit model shares the general idea of introducing an additional state variable

[2]We are grateful to Jessica Wachter for providing us with her Matlab code.

to the traditional consumption-based CAPM with a variety of other macroeconomically founded asset-pricing models. Indeed, other consumption-based models, such as the long-run risk model of Bansal and Yaron (2004) are popular and describe both US stock price and bond yield dynamics (Hasseltoft, 2012). Models taking account of rare disasters (Farhi and Gourio, 2018) and additionally allowing for a decline in inflation risk (Miller et al., 2020) explain the movements of stock prices and government bond yields in the US as well.

We calibrate the Wachter (2006) model for each of the six economies under study separately. In addition, we feed the model with consumption data to generate artificial time series of bond yields and price-consumption ratios and compare them with the time series patterns of their counterparts in the data.

Our calibrations aim at matching the mean ten-year nominal government bond yield and the stock market's Sharpe ratio of each of the sample countries. The model achieves this aim for Canada, Switzerland and the US, but not for Germany, Japan and the UK. The reasons differ across the latter three countries. In Germany, variation in the stock market return primarily reflects variation in cash dividends and other cash flows to shareholders (Stehle and Schmidt, 2015). This feature of the German stock market data is incompatible with the model in which stock prices only vary because of time-varying expected returns. Japan is a special case for two reasons. First, the Bank of Japan has purchased Japanese government bonds since 2001 and recently introduced yield curve control, i.e., it plans on keeping the ten-year government bond yield close to zero (Bank of Japan, 2001, 2016). These central bank interventions make it hard for the economic mechanism of the habit model to describe Japanese government bond yields. Second, the sample Sharpe ratio of the Japanese stock market is negative. This finding constitutes a challenge for every model that implies a positive risk premium for risky assets, such as equity. The UK is a challenge for the habit model because it is the only country in our sample for which the short-term real interest rate in the data is positively correlated with an empirical proxy of surplus consumption. This observation is in line with estimates provided by Engsted et al. (2010). However, matching the UK stock market's Sharpe ratio in the calibration of the model requires real, short-term interest rates to be negatively correlated with surplus consumption.

In the second part of our analysis, we feed the model with consumption and consumer price data to generate model-implied time series of nominal bond yields and price-consumption (price-dividend) ratios for each country.

The model implies that bond yields in the latter half of the sample period are lower than in the first half of the sample period. Hence, long-term bond yields follow the downward trajectory observed in the data. The exception is Japan. Furthermore, the model-implied bond yields for the US temporarily deviate substantially from their counterparts in the data. This finding is most pronounced in the period between 2010 and 2015 when the model predicts increasing long-term nominal US government bond yields while they remained low in the data.

The model also generates term spreads whose long-run time variations are similar to the dynamics of actual term spreads for most countries in the sample. If the expectations hypothesis held, term spreads would be constant (Fama, 2013). They are not constant in the data and the model qualitatively captures these features of the data.

We also find that model-generated time series of price-consumption ratios are broadly in line with the time series of observed price-dividend ratios. That being said, model-implied price-consumption ratios deviate considerably from the data during specific periods. For some countries, the period of the technology stock boom in the late 1990s constitutes a major challenge for the habit model. For other countries, the global financial crisis appears to be a major obstacle to matching the time variation of price-dividend ratios in the data. However, model-generated price-consumption ratios predict actual real stock market returns one-year ahead. For the reasons mentioned above, Germany and the UK are the exceptions in this respect.

Overall, our results show that fear of recession together with declining inflation expectations help to make economic sense of both falling and currently low nominal government bond yields and the dynamics of stock market valuation ratios internationally. The habit model provides a useful and intuitively appealing benchmark model for the joint dynamics of government bond yields and stock prices.

The remainder of the paper is organized as follows. We briefly summarize the related literature in section 2. Section 3 provides information about the data. Section 4 summarizes the main features of the external habit model. Section 5 provides information about parameter choices for the calibration of the habit model for each country. Section 6 presents our main findings and section 7 concludes. The appendix presents additional results and gives details of the country-specific model solutions.

2 Related literature

Papers trying to make sense of both bond yield and stock price dynamics in the past thirty years are rare. Notable exceptions are Farhi and Gourio (2018) who argue that taking account of increased disaster risks (Rietz, 1988; Barro, 2009) helps to explain the level of real interest rates and the level of stock prices relative to fundamentals, such as dividends or earnings, in the US. Miller et al. (2020) argue that a decline in inflation risk, i.e., surprise changes in inflation, on top of disaster risk explains relatively stable ratios of stock prices to fundamentals and declining nominal government bond yields in the US. In this model, the decline of inflation risks rationalizes the decline in nominal bond yields while stable valuation ratios in the US stock market are consistent with constant real interest rates. However, these papers focus on the US and do not assess whether their preferred models also perform well when confronted with data from other countries. The question of whether there is an economic mechanism that makes sense of bond yield and stock price dynamics internationally is the focus of our paper.

Our preferred model is the Wachter (2006) extension of the Campbell and Cochrane (1999) habit model because we argue that the economic mechanism of this model has the potential to replicate common variation in bond yields and stock prices in our sample countries. In addition, it could also account for cross-country differences that we observe in the data. Hence, our paper is related to studies using the habit model of Campbell and Cochrane (1999) to analyse cross-sectional and time series variation in international stock market returns (Li and Zhong, 2005; Darrat et al., 2011). These papers, however, do not analyse bond markets. In addition, they take the perspective of global investors and regard "world" representations of the habit model and other consumption-based models. Thus, the parameters of the habit model reflect average moments across the sample countries. We calibrate the habit model using country-specific parameters to match both stock market and bond market data and to assess whether the model generates time series of price-consumption ratios and bond yields that follow the general patterns in the country-specific data. Furthermore, our results suggest that taking cross-country differences in the preference parameters into account is important.

International evidence on the habit model's explanatory power for the term structure of interest rates outside the US is scarce. There is evidence on the performance of the habit model for the term structure of interest rates in the UK. Hyde and Sherif (2010) compare the explanatory power of different consumption-based models for the term structure of interest rates in the UK and find that the Wachter (2006) model provides the economically most plausible description of the data. Madueira (2007) uses the habit model to derive ex ante measures of an inflation risk premium and the real interest rate from nominal and inflation-indexed bonds. However, these papers focus on the bond market and do not explicitly assess the implications for the UK stock market or asset markets in other countries.

Our paper assesses the implications of the habit model for both the term structure of bond yields and stock prices for six countries. In this respect, Engsted at al. (2010) are closely related to our paper. Engsted et al. (2010) estimate the Wachter (2006) version of the Campbell and Cochrane (1999) habit model for eight different countries using more than 50 years of annual data up to 2004. They evaluate this model's explanatory power for asset returns in comparison with simple versions of the consumption-based, asset-pricing model. Moreover, they evaluate the habit model's predictive power for stock market returns and returns on long-term bonds. We exploit the additional features of the Wachter (2006) version of the consumption habit model to assess the model implications for the whole term structure of nominal bond yields. Moreover, we calibrate the model for each country to match bond market and stock market moments for the sample period from 1988 to 2019. This period includes the global financial crisis and great recession, an extended period of monetary policy interest rates close to their effective lower bounds and the advent of hitherto unconventional monetary policy measures (e.g., large-scale government bond purchases) in most of the countries under study. In addition, we explicitly evaluate whether feeding the habit model with consumption and consumer price data allows one to replicate time series patterns of bond yields and price-dividend ratios in the data.

3 Data

Our sample starts in the first quarter of 1988 because this is the date at which data of the term structure of interest rates are available for all of the countries in our sample. The sample ends in the fourth quarter of 2019. We focus on six economies (Canada, Germany, Japan, Switzerland, the United Kingdom, and the United States) for which we could obtain data on government bond yields, stock prices and macroeconomic aggregates covering the entire sample period.

Stock market data are from MSCI and are freely available on the MSCI website. MSCI indices offer the advantage that their construction and the coverage in terms of market capitalization are comparable across countries. We construct annual and quarterly stock prices and price-dividend ratios from monthly (end of month) data. Monthly price-dividend ratios are calculated as the log of the sum of monthly dividends over the past year minus the log of this month's MSCI price index. Dividend series are obtained from the difference between the returns on the MSCI gross (i.e., total return) index and the returns on the MSCI price index.

Government bond data are from national sources. We obtained Canadian zero-coupon bond yields from the website of the Bank of Canada and information about the Nelson-Siegel-Svensson coefficients of German government bonds to construct the German yield curve from the website of Deutsche Bundesbank. Japanese government bond data are from the website of the Japanese ministry of finance. Zero coupon yields (Nelson-Siegel-Svensson coefficients) from Swiss government bonds can be obtained from the website of the Swiss National Bank. UK bond yields are from the Bank of England. We use the updated zero coupon bond yields from Gürkaynak et al. (2007) for the US. We employ short-term government debt as an approximation to the risk-free interest rate for countries with a liquid secondary market for short-term government debt (UK and US) and short-term money market interest rates for all of the other countries.

Data on consumption, consumer prices and population are from the IMF's International Financial Statistics. Consumer price indices (CPI) and total household consumption data are seasonally adjusted.[3] We interpolate from annual population data to obtain quarterly population numbers.

[3]Ideally, one would use households' consumption of non-durables and services in the analysis. However, these subcomponents of total household consumption are not available (either in general or not for the entire sample period) for most of the countries in our sample. Therefore, we use total household consumption.

4 Consumption habits: main features of the model

This section summarizes the main features and technical assumptions underlying the consumption-based habit model. The summary follows closely the exposition in Campbell and Cochrane (1999) and Wachter (2006).

4.1 Basics

The point of departure of the model is the assumption that identical agents maximize the utility function

$$u(C_t, X_t) = E \sum_{t=0}^{\infty} \beta^t \frac{(C_t - H_t)^{1-\gamma} - 1}{1-\gamma} \tag{1}$$

in which H denotes the level of consumption habit (one can also think of it as the subsistence level of consumption), β measures impatience and is a number smaller than one, and C denotes consumption.

Campbell and Cochrane (1999) assess the link between consumption and the habit level by defining the surplus consumption ratio, S, as follows

$$S_t \equiv \frac{C_t - H_t}{C_t} \tag{2}$$

and $s = ln(S)$. Low surplus consumption represents a bad state of the world in which agents are more risk averse than in a state of the world in which consumption is far away from the habit level, i.e., surplus consumption is high.

The process of log surplus consumption follows

$$s_{t+1} = (1-\phi)\overline{s} + \phi s_t + \lambda(s_t)(\Delta c_{t+1} - E\Delta c_{t+1})) \tag{3}$$

in which $\overline{s}$ is the steady state value of log surplus consumption. This specification makes sure that surplus consumption is never negative and that surplus consumption moves in the same direction as consumption. The sensitivity function $\lambda(s_t)$ is chosen to fulfil a number of conditions that we discuss further below.

In the model, consumption follows a random walk with drift

$$\Delta c_{t+1} = g + v_{t+1}; v_{t+1} \sim N(0,1) \tag{4}$$

Since the habit formation is external[4], the identical agents choose the same level of consumption (and habit) and the marginal utility of the representative agent in this economy boils down to

$$u_c(C_t, X_t) = (C_t - H_t)^{-\gamma} = S_t^{-\gamma} C_t^{-\gamma} \tag{5}$$

which indicates that the intertemporal marginal rate of substitution of consumption (the stochastic discount factor, M) is

$$M_{t+1} = \beta \left(\frac{S_{t+1}}{S_t} \frac{C_{t+1}}{C_t} \right)^{-\gamma} \tag{6}$$

Adding habits to the power utility function makes risk aversion a function of the curvature of the utility function and surplus consumption, i.e., $-\frac{Cu''(C)}{u'(C)} = \gamma \left(\frac{C}{C-H} \right) = \frac{\gamma}{S}$.

The return on the traded risky asset i satisfies the Euler equation

$$E_t[M_{t+1} R_{t+1}^i] = 1 \tag{7}$$

[4]External habits only depend on past consumption. Internal habit formation would also relate the habit level to expectations of future consumption. Campbell and Cochrane (1999) show that the choice of external or internal habit formation does not affect the qualitative solutions to the model but the external habit formation is convenient for modelling purposes.

and the risk-free rate, whose expected payoff is known in advance, obeys

$$R^f_{t+1} = \frac{1}{E_t[M_{t+1}]} \tag{8}$$

Expressing equation (8) in log terms and plugging in the expressions for log consumption growth and the log surplus ratio gives

$$\begin{aligned} r^f_{t+1} &= ln\left(\frac{1}{E_t[M_{t+1}]}\right) \\ &= -ln(\beta) + \gamma g + \underbrace{\gamma(1-\phi)(\overline{s}-s_t)}_{\text{intert. smoothing}} - \underbrace{\frac{\gamma^2\sigma_v^2}{2}(1+\lambda(s_t))^2}_{\text{precaut. savings}} \end{aligned} \tag{9}$$

Wachter (2006) specifies the sensitivity function $\lambda(s_t)$ in such a way that the risk-free rate is also linearly related to the surplus consumption ratio in the last term of the right-hand side of equation (9), i.e., the term that reflects precautionary savings motives. The term $\gamma(1-\phi)(\overline{s}-s_t)$ represents the desire of agents to smooth consumption over time.

The effects of intertemporal smoothing and precautionary savings balance each other. When surplus consumption falls below its steady state value, the consumption smoothing motive leads to a fall in the risk-free real interest rate in order to induce consumption. By contrast, precautionary savings motives lead to an increase in the real risk-free rate when surplus consumption is below its steady state value.

The sensitivity function makes sure that the habit level is a function of past consumption and that the risk-free rate is linearly dependent on s_t:

$$\lambda(s_t) = (1/\overline{S})\sqrt{1-2(s_t-\overline{s})} - 1 \tag{10}$$

with, $\overline{S}$, the steady state value of surplus consumption that obeys

$$\overline{S} = \sigma_v \sqrt{\frac{\gamma}{1-\phi-b/\gamma}} \tag{11}$$

Moreover, to ensure that the term in the square root remains positive, $\lambda(s_t)$ is set to 0 when $s > s_{max}$[5], for

$$s_{max} = \overline{s} + \frac{1}{2}(1-\overline{S})^2 \tag{12}$$

These conditions give the equation for the risk-free rate

$$r^f_{t+1} = -ln(\beta) + \gamma g - \frac{\gamma(1-\phi)-b}{2} + b(\overline{s}-s_t) \tag{13}$$

which highlights that for $b \neq 0$, the risk-free rate varies over time with variation in surplus consumption relative to its steady state value, $\overline{s}$. If $b > 0$, surplus consumption below its steady state value drives down the risk-free rate, which indicates that the effects from intertemporal smoothing motives dominate. If $b < 0$, surplus consumption below the steady state value leads to an increase of the risk-free rate, which indicates that the precautionary savings motive dominates.

4.2 Bond and equity prices

Bond and equity prices follow from the basic ingredients of the model described in the previous subsection. They can be obtained by using techniques from the literature of affine bond pricing combined with numerical integration. We refer the reader to Wachter (2006) for the technical details and just briefly summarize the main intuition behind the determination of prices of real bonds, nominal bonds and stocks. The exposition closely follows Wachter (2006).

[5]This case rarely occurs when generating artificial data from the model.

Bonds are expressed as zero-coupon bonds. The prices of real bonds ($P_{m,t}$) with maturity m are functions of the surplus consumption ratio. They are determined recursively from the pricing equation

$$P_{m,t} = E_t \left[\beta \left(\frac{S_{t+1}}{S_t} \frac{C_{t+1}}{C_t} \right)^{-\gamma} P_{m-1,t+1} \right] \tag{14}$$

exploiting that the distribution of future consumption and surplus consumption only depend on s_t. The boundary condition for the recursive calculation is $P_{0,t} = 1$ because the real bond at $m = 0$ is worth one unit of consumption.

The prices of nominal bonds ($P^{Nom}_{m,t}$) with maturity m are not only functions of the surplus consumption ratio but also depend on time variation in expected inflation. The pricing equation for nominal bonds hence obeys

$$P^{Nom}_{m,t} = E_t \left[\beta \left(\frac{S_{t+1}}{S_t} \frac{C_{t+1}}{C_t} \right)^{-\gamma} \frac{\Pi_t}{\Pi_{t+1}} P^{Nom}_{m-1,t+1} \right] \tag{15}$$

with Π denoting aggregate consumer prices. The boundary condition for the recursive determination of the nominal bond price is $P^{Nom}_{0,t} = 1$.

In order to apply the same recursive computation for bond and equity prices, Wachter (2006) proposes to express equity prices as zero-coupon securities that promise an endowment of C_{t+m} in m periods with price $P^e_{m,t}$. It is convenient to rewrite the pricing equation for these securities in terms of price-consumption ratios, i.e.,

$$\frac{P^e_{m,t}}{C_t} = E_t \left[\beta \left(\frac{S_{t+1}}{S_t} \right)^{-\gamma} \left(\frac{C_{t+1}}{C_t} \right)^{1-\gamma} \frac{P^e_{m-1,t+1}}{C_{t+1}} \right] \tag{16}$$

The boundary condition is $P^e_{0,t} = C_t$.

Then, the price-consumption ratio of the aggregate stock market ($\frac{P_t}{C_t}$) is the sum of the price-consumption ratios of the zero-coupon securities, $\frac{P_t}{C_t} = \sum_{m=1}^{\infty} \frac{P^e_{m,t}}{C_t}$.

Alternatively, one could model equity prices as claims to dividends instead of linking them to consumption. This separation would take into account that dividends and consumption follow different processes in the data. However, Campbell and Cochrane (1999) show that modelling stock prices as either claims to consumption or claims to dividends yields the same results. Hence, we model stock prices as claims to consumption and compare the model-implied price-consumption ratios with price-dividend ratios in the data in the subsequent sections.

In the remainder of the paper, we use the following notation. Gross returns on m-period bonds (real, nominal) are

$$R_{m,t} = \frac{P_{m-1,t+1}}{P_{m,t}}$$

and

$$r_{m,t} = ln(R_{m,t}).$$

Yields are linked to bond prices through

$$y_{m,t} = -\frac{1}{m} ln(P_{m,t}).$$

5 Parameter estimates and calibration choices

The calibration of the habit model relies on stock and bond market data to pin down preference parameters. In addition, the model calibration for each country needs information about mean consumption growth (in real and per capita terms), the variance of consumption growth, and the correlation between inflation and consumption growth. Moreover, calculating nominal bond yields within the model requires the specification of a process for expected inflation.

We follow Wachter (2006) and assume that expected inflation is exogenously determined by an AR(1) process, i.e., expected inflation only depends on realized inflation. In the model, consumption growth is assumed to be independently and identically distributed across time. However, in order to determine the parameters of the inflation process, Wachter (2006) considers potential interdependencies between inflation and measured consumption growth by estimating

$$\Delta c_{t+1} = (1-\psi_1)g + \psi_1 \Delta c_t + \theta_1 v_{1,t} + v_{1,t+1} \tag{17}$$

$$\Delta \pi_{t+1} = (1-\psi_2)\overline{\pi} + \psi_2 \Delta \pi_t + \theta_2 v_{2,t} + v_{2,t+1} \tag{18}$$

in which the errors, $v_{1,t+1}$ and $v_{2,t+1}$, are correlated with each other.

Equations (17) to (18) are estimated using maximum likelihood separately for all of the countries under study. The estimation results are summarized in Table (1). The estimates reveal pronounced cross-sectional differences in mean consumption growth and inflation. However, the correlation between consumption growth innovations and inflation innovations is negative for all of the countries in our sample, which suggests that the average inflation risk premium for each country's nominal government bond yields is positive[6] during our sample period (Wachter, 2006).

[Table (1) about here]

Expected inflation tracks the low frequency movements in realized inflation. Figure (3) shows that expected inflation peaks at the beginning of the 1990s for all countries under study and falls until the beginning of the 2000s. Since then, expected inflation hovers around relatively low levels.

[Figure (3) about here]

We follow Wachter (2006) and tie the habit persistence parameter ϕ to the first-order autocorrelation of the respective country's price-dividend ratio

[6]The negative correlation between innovations in inflation and innovations in consumption growth implies that, on average, times of unexpectedly low consumption growth coincide with unexpectedly high inflation. This makes nominal bonds risky, which commands a positive risk premium.

in the data. Moreover, β in equation (13) is set in such a way that the population mean of the nominal risk-free rate in the model is close to the sample mean of the empirical approximation of the nominal risk-free rate for each country in the data.

We search for values of the parameters b, the parameter that governs the risk-free rate's link to surplus consumption, and γ, the parameter that represents the curvature of the utility function, so that the calibrated model replicates the Sharpe ratio of the excess return of each country's stock market and the respective sample mean of the ten-year nominal government bond yield. The calibrations could also impose restrictions to take into account the volatility of bond yields, cross-sectional restrictions on the yield curve or other stock return moments. However, we aim at calibrating the model imposing as little restrictions as possible to assess whether the model needs further restrictions to provide a better description of the data in the first place.

While the calibration of the model for the US allows one to first search for γ to match the Sharpe ratio and then find an appropriate value of b that additionally matches the bond yield data, this iterative approach does not work for the other countries in our sample. For these countries, we have to find a combination of b and γ that is a compromise between our calibration goals of capturing the sample average of the Sharpe ratio of the respective stock market and the sample mean of ten-year government bond yields.

In the case of Germany, Japan and the UK, we could not find a parameter combination that fulfils this task in a satisfactory way. We either match the mean ten-year bond yield or the Sharpe ratio of the stock market excess return, but not both. Germany is a challenge because German stock market returns seem to be mainly driven by cash flows to shareholders. Stehle and Schmidt (2015) show that prices of existing equity of German firms tend to be stable over time and that most German equity price increases reflect cash dividends and stock dividends or rights issuances. In the habit model, expected returns rather than expected cash flows drive stock prices. Consistent with this reasoning, Engsted et al. (2010) show that German stock market returns are not predictable by the German surplus consumption ratio in their sample period from 1950 to 2004.

Matching Japanese government bond yield and stock market data is a challenge for the model because the Bank of Japan intervenes in government bond markets and since 2016, targets long-term bond yields for monetary policy purposes. Moreover, the sample Sharpe ratio of the Japanese stock market excess return is negative. Hence, Japan is not only a challenge for the habit model but for all asset-pricing models.

The UK is a challenge because our empirical approximation to the real risk-free interest rate in the UK is positively correlated with surplus consumption, i.e., the precautionary savings motive dominates in the UK and thus, high surplus consumption is associated with a high real, short-term interest rate. However, matching the UK stock market data in our sample requires real, short-term interest rates to be negatively correlated with surplus consumption.

In the subsequent section, we present calibration results based on the parameter combinations for Germany and the UK for which we fit the respective country's average ten-year government bond yield reasonably well. For completeness, the appendix (A) gives the parameter combination that helps to explain the stock market's Sharpe ratio best and provides one example of how this parameterization affects the model's ability to replicate bond market evidence in Germany and the UK.

The choice of value for the parameter, b, that governs time-variation in the real, risk-free rate is a particularly contentious issue. Without clear guidance from theory or related empirical work[7], we opted to perform a grid search[8], so that the combination of the parameters b and γ matches the average nominal yield on ten-year government bonds for each country and the Sharpe ratio of stock market returns in the data as closely as possible.

Table (2) summarizes the parameter values for all countries and the derived parameters from simulating the model for each country separately. It turns out that for half of the countries, we need a combination of a utility curvature (γ) of slightly above unity with a small and positive b to match moments of stock market excess returns and bond yields best. Exceptions include the US, for which a higher value of γ is needed than for any other country, and Japan, for which the lowest value of γ and the highest value of b is needed for the calibrations. Furthermore, the parameter b has to be negative in order to match the UK yield curve. Regressions of measures of the real, short-term risk-free rate on an empirical approximation of surplus consumption presented in appendix (B) further support this parameter choice. This finding is also reflected in estimates of this parameter for the UK by Engsted et al. (2010).

[Table (2) about here]

[7] Campbell and Cochrane (1999) set $b = 0$. In this case, the effects of intertemporal smoothing and precautionary savings on the risk-free rate cancel each other out. By contrast, Wachter (2006) argues that $b > 0$ is in line with the data because, in her sample, the empirical proxy of the real, risk-free short-term interest rate in the US is negatively correlated with an empirical approximation of s_t, i.e., the intertemporal smoothing effect is stronger than the precautionary savings effect. However, Duffee (2013) shows that with more recent data, the correlation between the real risk-free rate in the US and the proxy of s_t is statistically not different from zero, but Ermolov (2019) argues that information about real interest rates from inflation-linked bonds supports the assumption of Wachter (2006). Finally, Verdelhan (2010) uses external habits in a two-country setting to explain deviations from the uncovered interest rate parity condition (UIP). In order to replicate the evidence of ex post deviations from the UIP with the consumption habit model, one needs to impose the restriction $b < 0$.

[8] We allowed the parameter b to vary from -0.05 to 0.05 and the parameter γ to range between 0.2 and 3.5.

6 Main results

This section presents our main results. The first subsection presents the outcomes of the calibration of the habit model for all six countries under study. The second subsection compares the dynamics of model-implied nominal bond yields and price-consumption ratios with their counterparts in the data. Appendix (C) summarizes the general characteristics of the model solutions for each country.

6.1 Calibration outcomes

6.1.1 Bond market

This subsection compares sample moments of nominal bond yields in the data with their model-implied values obtained after generating 100000 quarters of artificial data. We focus on nominal bond yields because we do not observe actual real bond yields for all of the countries under study.

Table (3) presents the comparison of mean bond yields of different maturities implied by the model with the mean bond yields we observe in our sample period from the first quarter of 1988 to the fourth quarter of 2019. We find that the model generates upward sloping average yield curves for almost all of the countries under study, which is also in line with the data. Japan is an exception. The habit model suggests a flat average yield curve while average nominal Japanese government bond yields increase with maturity in our sample period. The fact that the model faces problems matching Japanese bond yield data is not surprising given the long history of government bond purchases of the Bank of Japan and its recent introduction of yield curve control, i.e., conducting bond purchases such that the ten-year yield of Japanese government bonds stays close to zero (Bank of Japan, 2001, 2016).

We opted to calibrate the habit model to match the Sharpe ratio on the respective country's stock market excess return and the mean ten-year government bond yield for each country because ten-year yields are typically used as a benchmark for long-term interest rates. Table (3) shows that this calibration not only leads to a relatively close match between mean ten-year yields generated by the model and in the data, but it also allows us to describe average bond yields across different maturities for the countries under study reasonably well.

The model has more difficulties matching the average volatility of government bond yields. With the exception of Canada, the standard deviations of bond yields implied by the model are lower than those observed in the data. In some cases, volatility increases with maturity. In other cases, we observe the opposite pattern.

[Table (3) about here]

6.1.2 Stock market

This subsection compares moments of stock market excess returns in the data with their model-implied values. The calibration uses the Sharpe ratio (mean excess return divided by its standard deviation) of the countries' stock markets as a reference point in the calibration. The two components of the Sharpe ratio and the other return moments are outcomes of the calibration and are not imposed on the model. Table (4) summarizes the results.

The model matches the Sharpe ratios of Canada, Switzerland and the US exactly and generates combinations of stock market excess returns and standard deviations that are close to the values observed in the data. Average price-consumption ratios are considerably lower and less volatile than the actual price-dividend ratios in our sample period, but the model produces autocorrelations of price-consumption ratios that are consistent with the data.

As emphasized in section (5), it is not possible to match both the sample mean of ten-year government bond yields and the sample mean of the stock market's Sharpe ratio for Germany and the UK. We present the combination of parameters that focuses on matching bond yields. As a result, table (4) shows that the model implies Sharpe ratios for Germany and the UK that are about twice as high as those in the data. This finding results from the model's overestimation of the average stock market excess return. The other stock market moments are approximately equally well captured, as in the cases for Canada, Switzerland and the US.

Another special case is Japan. In our sample period, the Sharpe ratio of the Japanese stock market was slightly negative. Replicating this observation constitutes a challenge for every model that implies a positive risk premium for risky assets, such as equity. In addition, the calibration aims at matching the ten-year Japanese government bond yield, which has lately been the target of the Bank of Japan's monetary policy (Bank of Japan, 2016). As a consequence, the model generates implausibly high values in the unconditional mean of the price-consumption ratio in Japan.

[Table (4) about here]

6.2 Time series implications

6.2.1 Bond markets

This section compares time series of short-term interest rates, long-term bond yields and the spread between the two that are implied by the model with their counterparts in the data. We follow Wachter (2006) and generate the model-implied time series from quarterly real consumption growth per capita and equation (3) to obtain a time series of log surplus consumption. Moreover, we construct expected inflation from realized inflation as described in Appendix C of Wachter (2006).

We start with a comparison of the model-implied short-term nominal interest rates with the data in Figure (4). The time series are z-standardised. For all countries in our sample, nominal short-term interest rates in the data exhibit similar dynamics. They start at relatively high values at the beginning of the sample period and then fall, especially in the period of the global financial crisis, to low levels at the end of the sample period. The habit model replicates this long-run dynamic of short-term interest rates for most countries in our sample period. This is even the case for countries such as Germany and Switzerland for which the relevant short-term nominal interest rates have fallen into negative territory in our sample period. However, at the end of the sample period, the model implies increasing short-term nominal interest rates while they mainly remained flat at low levels in the data. This observation is most pronounced for the US in the period since the global financial crisis.

[Figure (4) about here]

The standardised long-term bond yields in the data and their counterparts implied by the habit model are depicted in Figure (5). We present the five-year yields as a robustness check of whether the calibration of the model to match ten-year yields provides a reasonable time series of bond yields with different maturities.

The model-implied, long-run dynamics of five-year bond yields are similar to those in the data, i.e., five-year yields at the end of the sample period are usually lower than those at the beginning of the sample period. The model-generated yields do not exhibit exactly the same short-run dynamics as the five-year yields in the data but they tend to follow a downward trajectory.

The fall of the nominal bond yields in the 1990s coincides with declining inflation expectations in this time period (see Figure (3)). Since 2000, the inflation expectations in all the countries in our sample did not vary much. This suggests that the fall in expected inflation already accounts for a large part of the decline in bond yields at the beginning of the sample period.

Not surprisingly, the model has difficulties capturing the dynamics of Japanese government bond yields. We also observe substantial deviations between the time series patterns of the US bond yields in the data and the model-implied yields since the global financial crisis. As the habit model is calibrated to long-term, government bond yields, it is tempting to at least partly attribute these deviations between habit model and data to the impact of quantitative easing on long-term yields. For example, Swanson (2020) shows that large-scale asset purchases had a persistent effect on US government bond yields, which may provide an explanation of why the model-implied US government bond yields exhibit such different dynamics than the actual yields after the global financial crisis. The model suggests increasing long-term yields between 2010 and 2015. In the data, nominal bond yields remain at low levels. More generally, global portfolio rebalancing associated with quantitative easing by major central banks could explain why the model-implied bond yields of all countries move higher than the actual yields at the end of our sample period (e.g., Christensen and Rudebusch, 2012).

[Figure (5) about here]

Finally, Figure (6) depicts the comparison between model-implied and actual term spreads, i.e., the spread between the five-year yields in Figure (5) and the short-term interest rates presented in Figure (4). If the expectations hypothesis held, term spreads would be constant (e.g., Fama, 2013). The term spreads generated by the habit model are on average less variable than the term spreads in the data, but they follow the general dynamics of the actual term spreads for all of the countries in our study. This finding reinforces the argument that time-varying risk premia help to explain the lack of empirical support for the expectations hypothesis in the data. Appendix D uses the regression setup proposed by Fama and Bliss (1987) and Campbell and Shiller (1991) to confirm this point.

[Figure (6) about here]

6.2.2 Stock markets

Does the model replicate the actual dynamics of stock prices, i.e., the price-dividend ratios, when we feed the model with consumption data? Figure (7) visualizes the answer to this question.

For some countries (Canada, Germany, Switzerland and the UK), the habit model has difficulties replicating the time series of price-dividend ratios around the time of the technology stock market boom in the late 1990s. The price-consumption ratios implied by the model do not increase to the same extent as the price-dividend ratios in the data during this particular time period. But the model more (Canada and Germany) or less (UK) captures the long-run movements of the price-dividend ratios for these countries.

Switzerland is a special case. The model produces a price-consumption ratio that declines substantially at the beginning of the 1990s, while the price-dividend ratio actually rose. One potential explanation for this finding is a Swiss-specific real estate crisis at the beginning of the 1990s (Drechsel and Funk, 2017). In this crisis period, consumption moved towards the habit level, which in turn increases risk aversion. As a consequence, the model suggests that the prices of stocks had to fall relative to consumption. However, the Swiss-specific real estate crisis did not really affect the Swiss stock market.

Interestingly, the Japanese price-consumption ratio generated by the model closely matches both long-run and short-run dynamics of the actual price-dividend ratio. This suggests that time-varying fear of recession is the main driver of Japanese stock markets in our sample period.

The model captures the long-run fluctuations of the US price-dividend ratios but has difficulties replicating the dynamics of the price-dividend ratios at the beginning of the sample period and the years immediately after the global financial crisis. The former finding has already been observed by Campbell and Cochrane (1999). However, our results highlight that the model replicates most of the time variation in the US price-dividend ratio until the global financial crisis. The great recession following the global financial crisis forced consumption closer to the habit level such that the price-consumption ratio had to fall whereas the price-dividend ratio barely moved in the data. This observation seems to be related to the finding from the previous subsection highlighting that long-term US bond yields remained low while the habit model would have predicted increasing bond yields. One could interpret our findings as showing that the monetary policy measures of the Fed reduced risk premia on financial markets and thus, stabilized bond yields, as well as stock prices. Consequently, the price-dividend ratio in the US remained stable during this period.

[Figure (7) about here]

As a final evaluation of the stock market implications of the habit model, we assess whether there is return predictability by the price-consumption ratios. Evidence in favour of predictability would support the view that fear of recession is the main driver of stock returns.[9]

We evaluate whether price-consumption ratios predict actual stock returns by running the regression

$$r_{t,t+1}^{real} = a + \delta(p-c)_t + \varepsilon_{t+1}$$

separately for each country in our sample. r^{real} denotes the inflation-adjusted log stock market return from year t to $t+1$ for each country and $p-c$ represents each country's log consumption-price ratio generated by the respective habit model. We run the regressions with annual data to work with non-overlapping data, which helps us to avoid econometric issues associated with the concatenation of log returns in long-horizon regressions. The sample period runs from 1988 to 2019. Table (5) provides the point estimates and t-statistics of the regression coefficients δ and the adjusted R^2 of the one-year ahead regressions.

[9] In the absence of rational bubbles, the ratio of stock prices to dividends has to forecast future stock returns, future dividend growth or both (Campbell and Shiller, 1988). Given the setup of the habit model used in this paper, model-implied price-consumption ratios can only predict expected stock market returns but not consumption/dividend growth.

We find that the habit model's price-consumption ratios in almost all countries exhibits the ability to forecast stock returns. A low price-consumption ratio predicts high future returns on the Canadian, Japanese, Swiss and the US stock market. The R^2 statistics vary between 7% (Japan) and 15% (Switzerland). Exceptions are Germany and the UK. The lack of predictability in German stock market returns is in line with evidence in Engsted et al. (2010) and Stehle and Schmidt (2015). The lack of predictive ability for the UK stock market returns can be explained by our calibration choice (see section 5). We chose to focus on the parameter combination that fits the ten-year UK government bond yield as closely as possible. As a result, we do not fit the stock market data well, which is also reflected in the forecast regression.

[Table (5) about here]

7 Conclusions

This paper has calibrated an asset-pricing model featuring consumption habits to assess whether increased fear of recesssion together with declining inflation expectations help to make sense of the joint dynamics of nominal government bond yields and stock prices in six major economies in the period from 1988 to 2019.

Our assessments show that the model provides a useful benchmark for the behaviour of stock prices and government bond yields internationally. The main results show that the model is able to match average yields and to replicate the long-run dynamics of nominal government bond yields in the data for most sample countries. This requires a calibration of the model that focuses on bond market data because there are major differences between countries with respect to the applicability of the habit model to match bond and stock market data jointly. However, even when focusing the model calibrations on bond yields, model-implied ratios of stock prices to consumption exhibit similar long-run dynamics as price-dividend ratios in the data for most countries. Furthermore, the price-consumption ratios generated by the model predict actual stock market returns.

Our sample period does not include the impact from the spread of the Covid-19 pandemic on macroeconomic aggregates and financial markets because we aim at an assessment of the general ability of the habit model to replicate the joint dynamics of stock prices and bond yields over a long period of time. Repeating this assessment after the full economic impact from the pandemic has become clear will be an interesting cross-check of our results.

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Tables

Table 1: Estimates of inflation process and consumption growth parameters

	CND	JPN	GER	CH	UK	US
g: mean cons. growth (%)	0.34	0.19	0.23	0.08	0.25	0.31
(standard error)	(0.06)	(0.08)	(0.07)	(0.04)	(0.21)	(0.13)
$\overline{\pi}$: mean infl. (%)	0.85	0.12	0.47	0.31	0.94	0.66
(standard error)	(0.55)	(0.07)	(0.11)	(0.15)	(0.51)	(0.14)
ψ_1: AR term for cons.	0.79	0.08	-0.00	0.98	0.91	0.94
(standard error)	(0.14)	(0.34)	(0.29)	(0.04)	(0.05)	(0.06)
ψ_2: AR term for infl.	0.99	0.81	0.94	0.92	0.99	0.97
(standard error)	(0.01)	(0.05)	(0.06)	(0.05)	(0.01)	(0.05)
θ_1: MA term for cons.	-1.21	-0.27	-0.17	-0.99	-0.72	-0.88
(standard error)	(0.15)	(0.34)	(0.29)	(0.02)	(0.08)	(0.07)
θ_2: MA term for infl.	-0.87	-1.32	-0.83	-0.76	-0.86	-0.93
(standard error)	(0.04)	(0.09)	(0.10)	(0.08)	(0.04)	(0.08)
σ_1: st. dev. for cons. (%)	0.67	1.11	0.95	0.66	0.79	0.71
(standard error)	(0.11)	(0.07)	(0.06)	(0.04)	(0.05)	(0.04)
σ_2: st. dev. for infl. (%)	0.58	0.44	0.46	0.58	0.58	0.59
(standard error)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.03)
ρ: correlation	-0.50	-0.69	-0.40	-0.54	-0.54	-0.46
(standard error)	(0.07)	(0.05)	(0.08)	(0.06)	(0.06)	(0.05)

Notes: This Table provides maximum likelihood estimates of the model

$$\Delta c_{t+1} = (1-\psi_1)g + \psi_1 \Delta c_t + \theta_1 v_{1,t} + v_{1,t+1}$$
$$\Delta \pi_{t+1} = (1-\psi_2)\overline{\pi} + \psi_2 \Delta \pi_t + \theta_2 v_{2,t} + v_{2,t+1}$$

using quarterly data on log real, per capita consumption growth (Δc) and log inflation ($\Delta\pi$). AR denotes autoregressive coefficients. MA denotes moving average coefficients and ρ represents the correlation between the consumption growth and inflation innovations, v_1 and v_2. The sample period for the estimations starts in the first quarter of 1988 and ends in the fourth quarter of 2019. The countries under study are Canada (CND), Japan (JPN), Germany (GER), Switzerland (CH), the United Kingdom (UK) and the United States (US).

Table 2: Preference parameters

	CND	JPN	GER	CH	UK	US
Parameters matching stock and bond market data						
γ	1.1700	0.7290	1.1875	1.4900	1.1360	2.82
b	0.0058	0.02	0.00044	0.00045	-0.00034	0.0064
ϕ	0.96	0.97	0.92	0.95	0.93	0.97
Derived parameters						
β	0.9834	0.9991	0.9544	0.9651	0.9587	0.9638
$\overline{s}$	-3.2310	-1.0121	-3.3051	-3.2951	-3.4822	-2.6961
s^{max}	-2.7318	-0.5781	-2.8058	-2.7958	-2.9827	-2.1984

The upper panel of this Table presents the preference parameters that have been chosen to match specific moments of stock market excess returns and bond yields. The utility curvature (γ) and the coefficient on $-s_t$ in the risk-free rate equation (b) are chosen so that the model matches the sample average ten-year nominal government bond yield and the sample Sharpe ratio of the respective stock market in the data as closely as possible. Moreover, the persistence parameter of the consumption habit (ϕ) should match the first-order autocorrelation of the quarterly price-dividend ratio in the data. Country acronyms are defined in Table (1). The sample period runs from first quarter of 1988 to the fourth quarter of 2019.
The lower panel of this Table presents the parameters that follow from the choices of the other parameters. The value of the subjective discount factor, β, ensures that the average nominal risk-free rate of the model (at $s = \overline{s}$) is close to the approximation of the nominal risk-free rate in the data. The long-run mean of the log surplus consumption ($\overline{s} = ln(\overline{S})$) is set equal to $ln(\sigma_v \sqrt{\frac{\gamma}{1-\phi-b/\gamma}})$, in which σ_v denotes the standard deviation of the consumption growth innovation. The maximum value of the log surplus consumption (s^{max}) follows from $s_{max} = \overline{s} + \frac{1}{2}(1-\overline{S})^2$.

Table 3: Mean and standard deviations of nominal zero-coupon bond yields in the model and the data

	CND				GER			
	Mean		Std. Deviation		Mean		Std. Deviation	
Maturity	Model	Data	Model	Data	Model	Data	Model	Data
1	3.78	3.88	2.00	3.28	2.90	2.94	0.41	2.91
8	4.11	4.20	2.11	2.97	3.02	3.16	0.40	2.82
20	4.73	4.63	2.33	2.85	3.30	3.65	0.47	2.74
28	5.18	4.84	2.48	2.78	3.58	3.93	0.60	2.66
40	5.88	5.08	2.69	2.72	4.23	4.24	0.95	2.55
	JPN				CH			
	Mean		Std. Deviation		Mean		Std. Deviation	
Maturity	Model	Data	Model	Data	Model	Data	Model	Data
1	1.33	1.33	0.76	2.17	1.94	1.97	0.60	2.65
8	1.32	1.28	0.56	1.97	2.07	1.99	0.53	2.27
20	1.33	1.65	0.46	1.95	2.29	2.28	0.50	2.07
28	1.33	1.89	0.42	1.95	2.45	2.50	0.52	2.00
40	1.34	2.14	0.37	1.91	2.74	2.74	0.61	1.93
	UK				US			
	Mean		Std. Deviation		Mean		Std. Deviation	
Maturity	Model	Data	Model	Data	Model	Data	Model	Data
1	4.80	4.91	1.15	4.01	3.14	3.17	1.16	2.47
8	4.88	4.76	1.12	3.25	3.45	3.60	1.26	2.53
20	5.03	5.28	1.08	2.88	4.07	4.22	1.44	2.32
28	5.14	5.42	1.06	2.68	4.55	4.53	1.58	2.22
40	5.35	5.45	1.04	2.36	5.35	4.89	1.82	2.12

This Table presents mean nominal bond yields and the yields' standard deviations for different maturities (in quarters) in % p.a., distinguishing between actual data and model-generated bond yields. The sample period of the data ranges from the first quarter of 1988 to the fourth quarter of 2019. The means of model-generated bond yields are obtained after generating 100000 quarters of artificial data. Country acronyms are defined in Table (1).

Table 4: Comparing simulated and actual stock market data

	$E(r_m - r_f)$		$\sigma(r_m - r_f)$		Sharpe#		$E(P/D)$		$\sigma(p-d)$		$corr(p-d)$	
	model	data	model	data	model	data	model	data	model	data	model	data
CND	5.37	4.42	18.75	15.42	0.29	0.29	25.28	43.77	0.31	0.29	0.95	0.96
GER	9.72	5.05	20.63	23.36	0.47	0.22	10.70	44.97	0.23	0.33	0.91	0.92
JPN	0.10	-0.57	5.01	21.41	0.02	-0.03	629.23	95.73	0.06	0.50	0.97	0.97
CH	6.18	7.43	14.41	17.23	0.43	0.43	16.19	50.87	0.21	0.37	0.95	0.95
UK	9.02	3.30	20.19	14.45	0.45	0.23	11.66	29.66	0.24	0.19	0.91	0.93
US	6.50	7.35	13.37	15.11	0.49	0.49	18.58	50.55	0.23	0.29	0.96	0.97

Notes: The Table compares moments of stock market returns obtained from the model with stock return moments from the actual data. The excess return on the stock market $(r_m - r_f)$ in the data is the return on the respective country's MSCI gross (total return) index minus the three-month treasury bill or three-month money market rate. In the model, $r_m - r_f$ is the return on the consumption claim minus the one-period real risk-free rate. $\sigma(r_m - r_f)$ is the standard deviation of the excess return on the stock market. The Sharpe ratio is the mean excess return divided by the standard deviation of the excess return. Mean and standard deviation of the market return are in % p.a. $E(P/D)$ is the mean price-dividend ratio in the data and the mean price-consumption ratio in the model. The term $corr(p-d)$ denotes the autocorrelation of the log price-dividend ratio. The data frequency is quarterly. The data sample starts in the first quarter of 1988 and ends in the fourth quarter of 2019. # indicates a moment that is used as reference for the calibration of the preference parameters. The model-generated moments are obtained after generating 100000 quarters of artificial data. Country acronyms are defined in Table (1).

Table 5: Price-consumption ratios and one-year ahead stock return predictability

	CND	GER	JPN	CH	UK	US
δ	0.16	-0.00	1.17	0.62	0.02	0.32
(s.e.)	(0.08)	(0.26)	(0.63)	(0.27)	(0.05)	(0.14)
R^2	0.08	0.00	0.07	0.15	0.00	0.14

Notes: This Table presents results from the regression

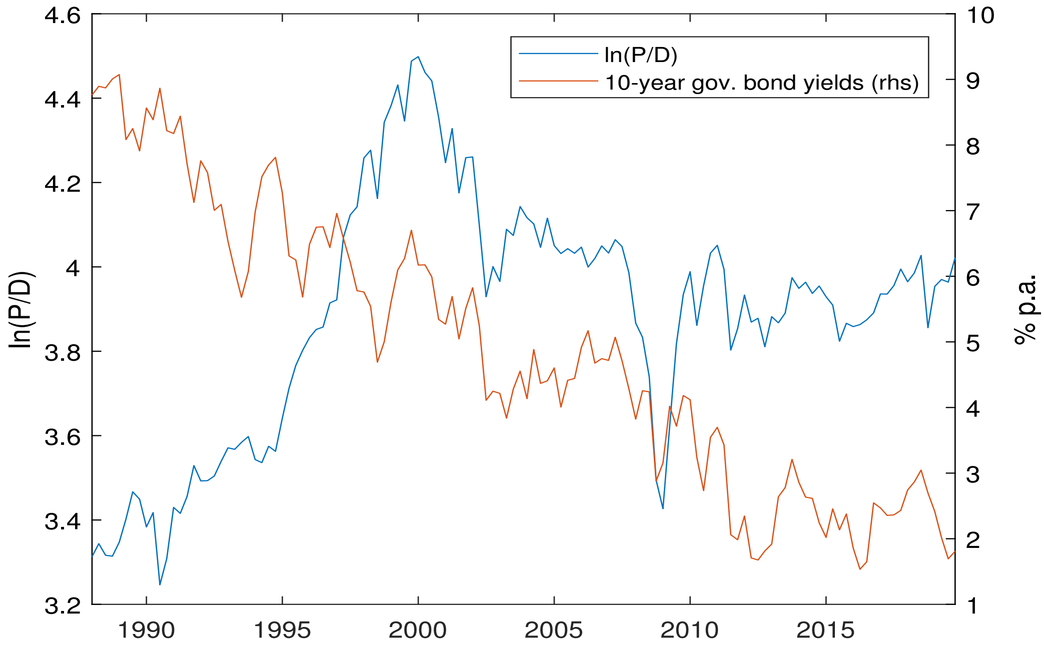
$$r^{real}_{t,t+1} = a + \delta(p-c)_t + \varepsilon_{t+1}$$

in which $r^{real}_{t,t+1}$ denotes the log real return on the MSCI stock market index of a respective country from year t to year $t+1$ and $p-c$ denotes annual values of the log price-consumption ratio from the habit model calculated from consumption data in the sample period.
The Table reports the regression coefficients, δ, the standard error in parenthesis (estimated with GMM using the delta method and adjusted for heteroskedasticity) and the adjusted R^2 . The sample period ranges from 1988 to 2019. Country acronyms are defined in Table (1).

Figures

Figure 1: 10-year government bond yields and log price-dividend ratios

(a) US



(b) CH

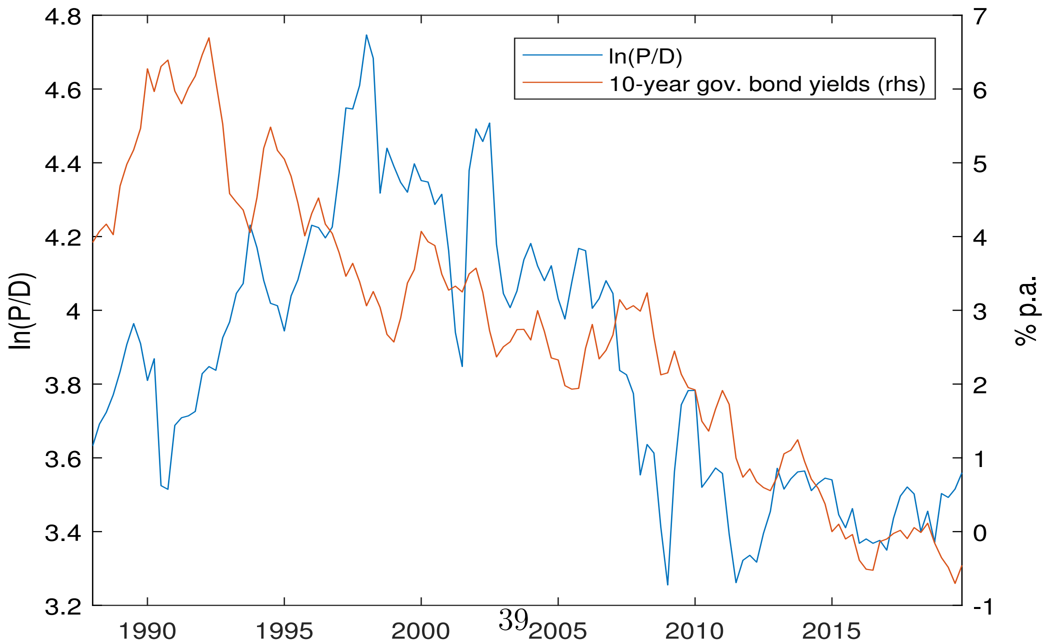
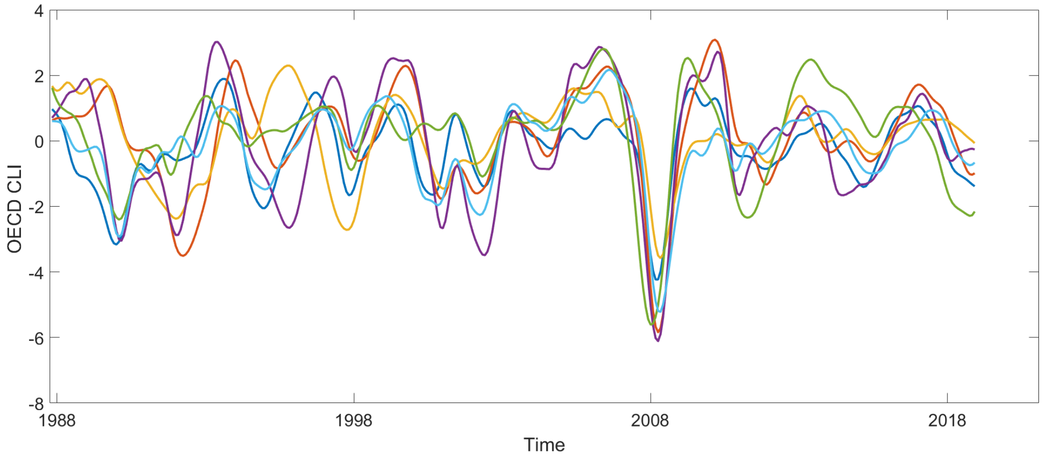


Figure 2: OECD composite leading indicators of business cycles



Notes: This Figure depicts the OECD's amplitude-adjusted composite leading indicators (CLI) of business cycles for the six countries (Canada, Germany, Japan, Switzerland, the United Kingdom and the United States) in our sample. The CLIs are interpretable as output gaps. The sample period ranges from the first quarter of 1988 to the fourth quarter of 2019.

Figure 3: Expected and realized inflation

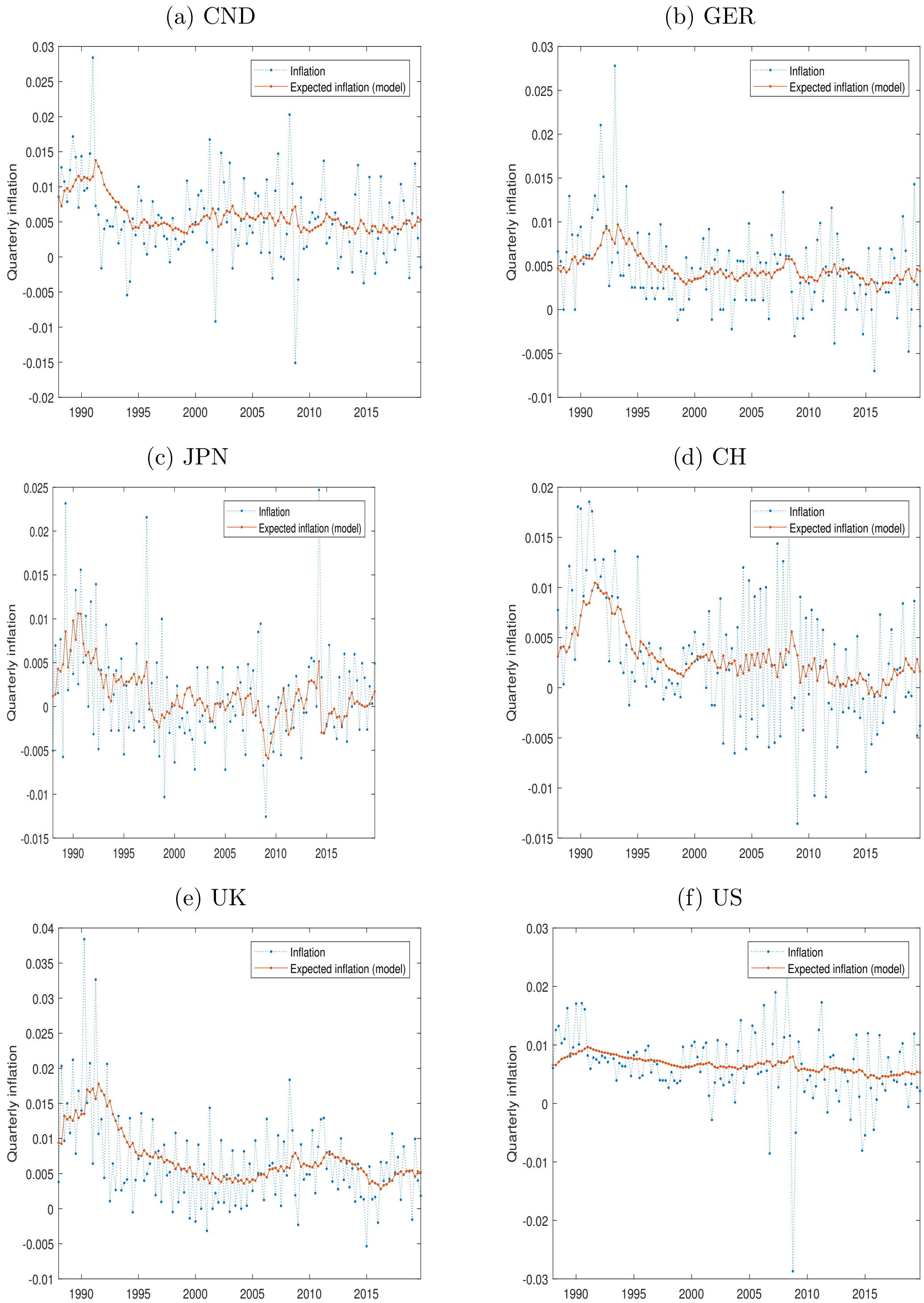


Figure 4: Time series of nominal risk-free rates

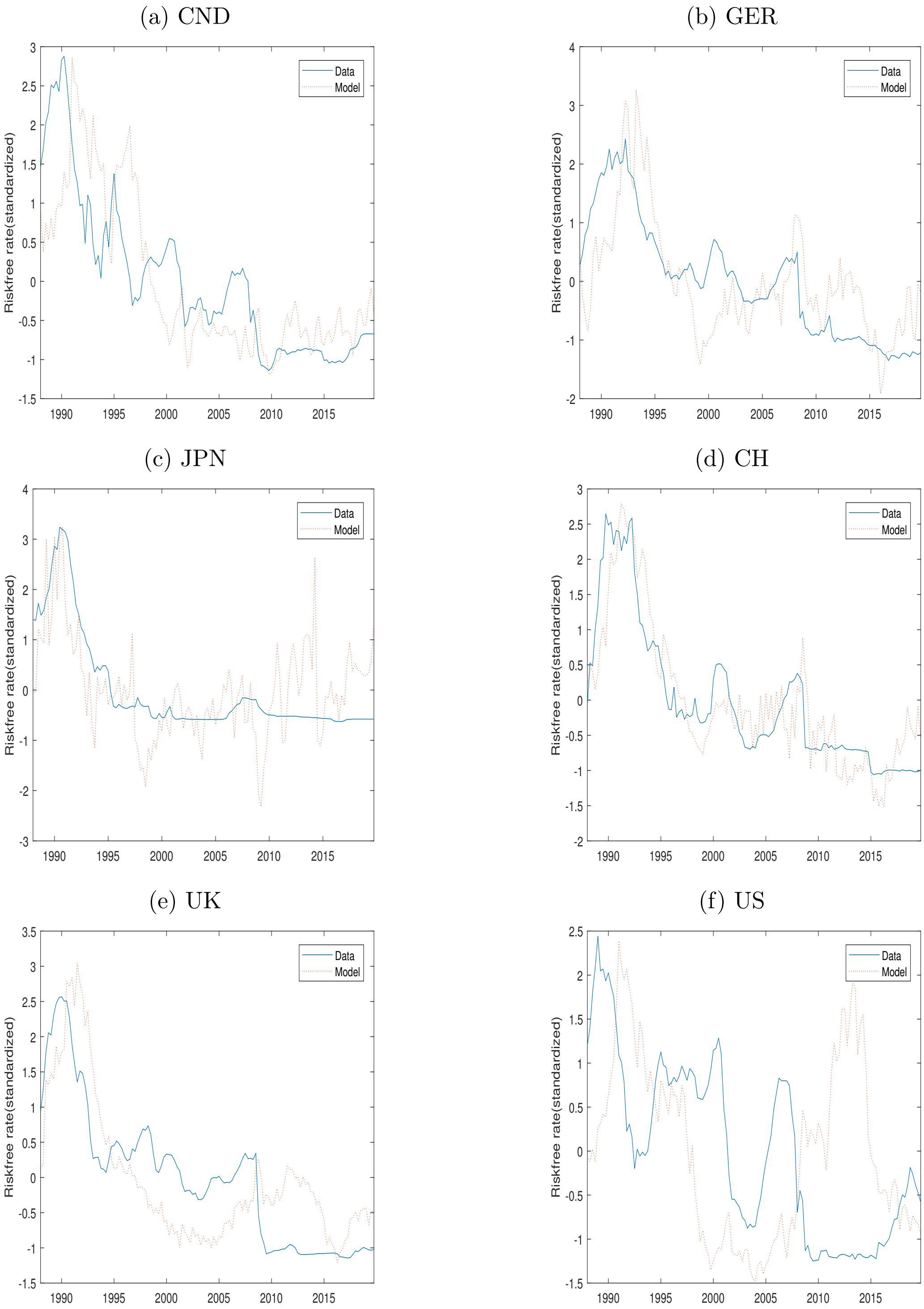
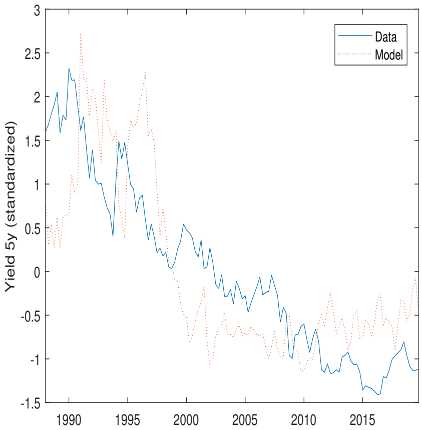
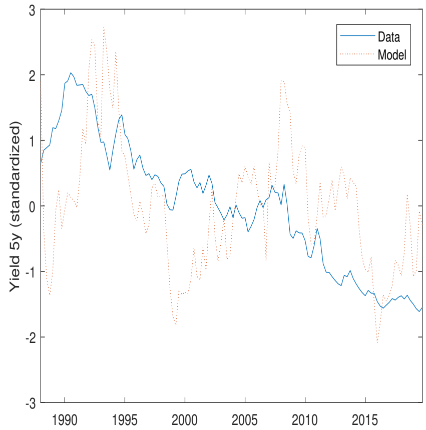


Figure 5: Time series of nominal five-year government bond yields

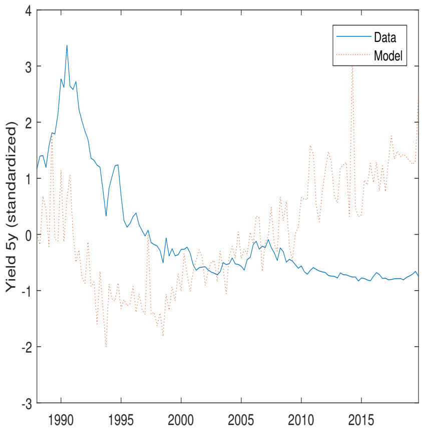
(a) CND



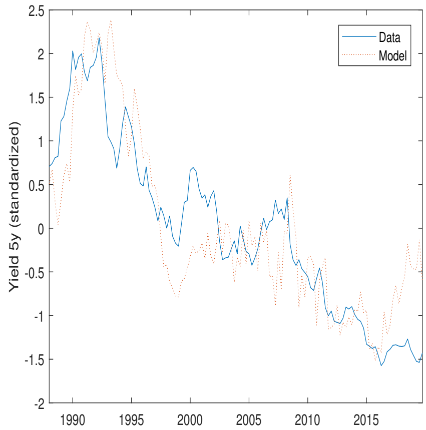
(b) GER



(c) JPN



(d) CH



(e) UK

(f) US

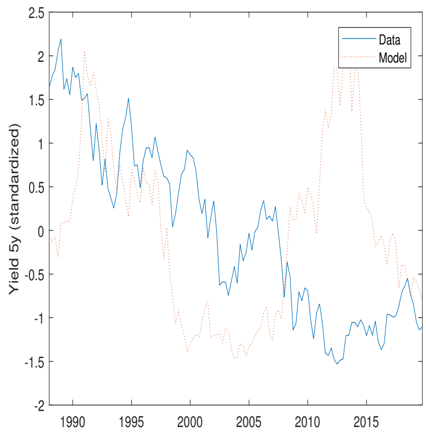
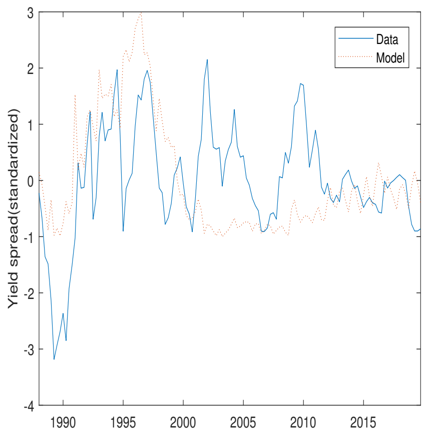
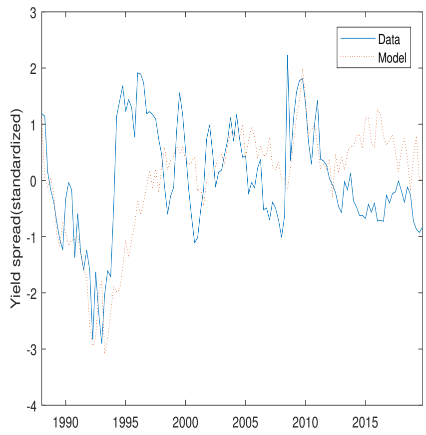


Figure 6: Time series of term yield spreads (5year - 3M)

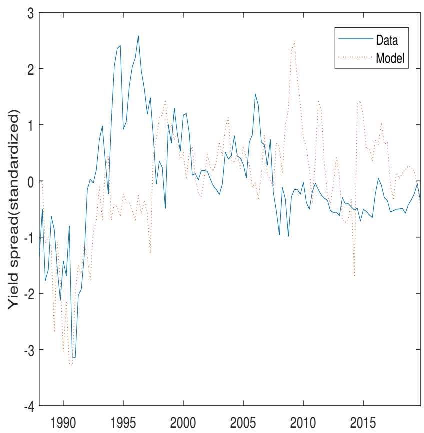
(a) CND



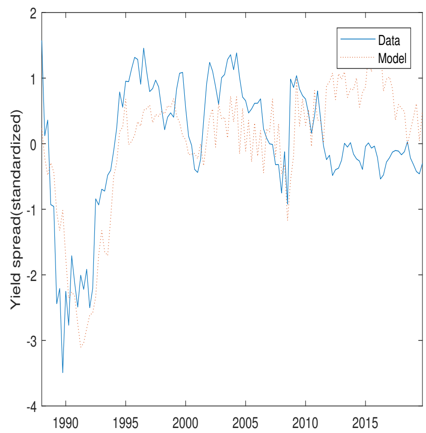
(b) GER



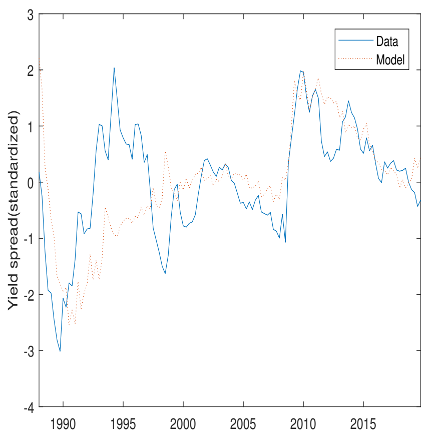
(c) JPN



(d) CH



(e) UK



(f) US

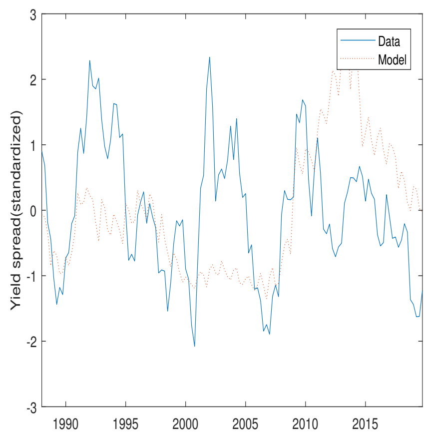
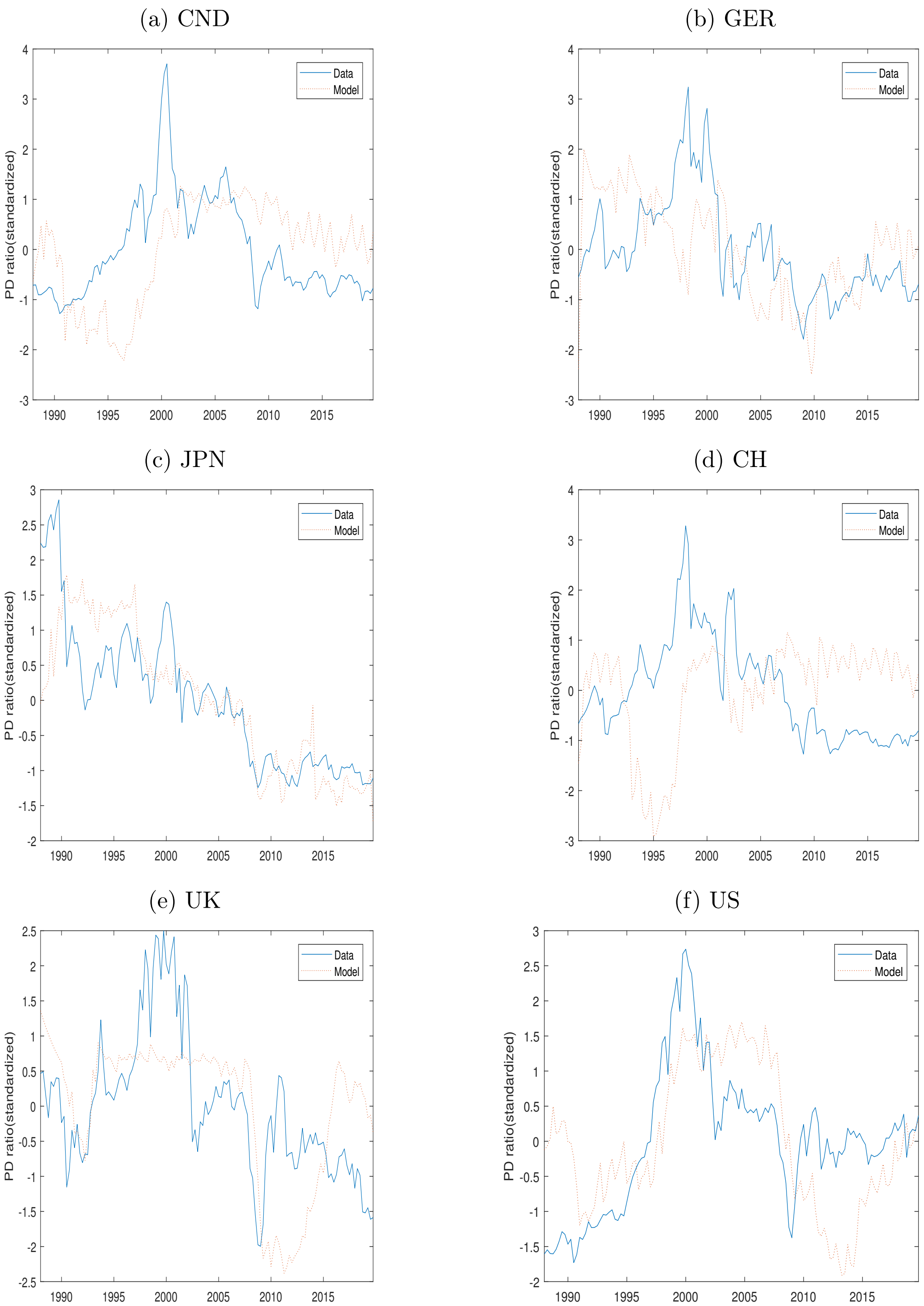


Figure 7: Actual P/D versus model-implied P/C



A Calibration outcomes and additional results for Germany and the UK

We highlighted in the main text that it is not possible to jointly match key moments of bond yields and stock market returns for Germany and the UK. This section presents a replication of some of the main results obtained with the calibration that focuses on matching the stock market's Sharpe ratio and largely disregards the bond yield data.

Table (6) compares the parameter values from the grid searches that delivered the best fit of the bond yield data with parameter values that provide the best fit for the Sharpe ratio. For both Germany and the UK, the utility curvature has to be lower and the parameter that governs how sensitively the real risk-free rate moves with surplus consumption has to be higher. In the case of the UK, the parameter, b, even switches its sign.

Table 6: Preference parameters

	GER		UK	
	bond focus	stock focus	bond focus	stock focus
	Parameters matching data			
γ	1.1875	0.75	1.1360	0.8025
b	0.00044	0.0283	-0.00034	0.0343
ϕ	0.92	0.92	0.93	0.93
	Derived parameters			
β	0.9544	0.9837	0.9587	0.9866
$\overline{s}$	-3.3051	-3.2158	-3.4822	-3.2298
s^{max}	-2.8058	-2.7166	-2.9827	-2.7305

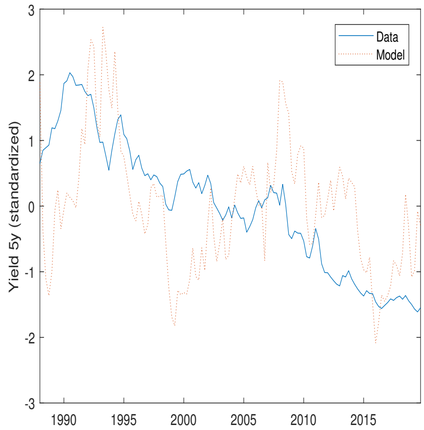
Notes: The upper panel in this Table presents the preference parameters that have been chosen for Germany and the UK so that the utility curvature (γ) and the coefficient on $-s_t$ in the risk-free rate equation (b) in the model match the Sharpe ratio of the respective country's stock market in the data as closely as possible. Moreover, the persistence parameter of the consumption habit (ϕ) should match the first-order autocorrelation of the quarterly price-dividend ratio in the data. Country acronyms are defined in Table (1).
The lower panel in this Table presents the parameters that follow from the choices of the other parameters. The value of the subjective discount factor, β, ensures that the average nominal risk-free rate of the model (at $s = \overline{s}$) is close to the approximation of the nominal risk-free rate in the data. The long-run mean of the log surplus consumption ($\overline{s} = ln(\overline{S})$) is set equal to $ln(\sigma_v \sqrt{\frac{\gamma}{1-\phi-b/\gamma}})$, in which σ_v denotes the standard deviation of the consumption growth innovation. The maximum value of the log surplus consumption (s^{max}) follows $s_{max} = \overline{s} + \frac{1}{2}(1-\overline{S})^2$.

This parameter choice strongly affects the bond market results. As an example of the consequences of these parameter choices, Figure (8) provides a comparison between the time series of five-year government bond yields for the different parameter choices. The Figures under the heading "bond calibration" are the ones that have been already discussed in the main text. The Figures under the heading "stock calibration" give the time series generated by the model when we use the parameters that focus on matching the respective Sharpe ratios to generate the model-implied government bond yields.

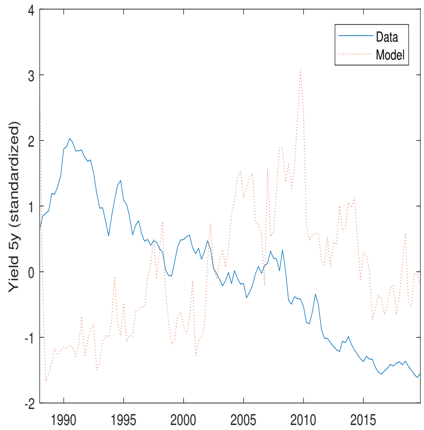
It is clear that the alternative calibrations to match the Sharpe ratios produces model-implied time series of bond yields that are at odds with the data. In the case of Germany, this observation mainly pertains to the beginning of the sample period. In the case of the UK, this observation is more general. Additional results are available upon request.

Figure 8: Time series of nominal five-year government bond yields

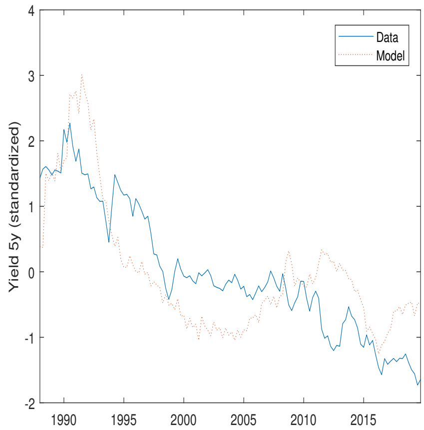
(a) GER: bond calibration



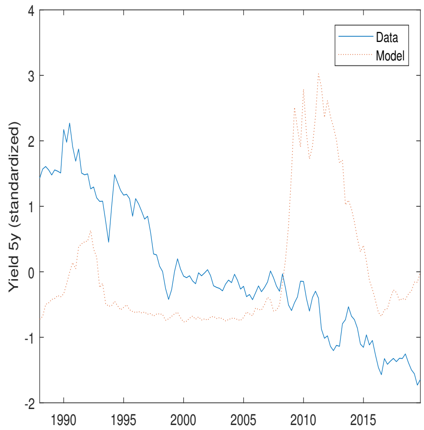
(b) GER: stock calibration



(c) UK: bond calibration



(d) UK: stock calibration



B The sensitivity of short-term real interest rates to a proxy of surplus consumption

This section briefly summarizes the outcomes of auxiliary regressions that provide guidance for the value of the parameter b, i.e., the parameter that determines how sensitive the risk-free real rate is to variation in surplus consumption. We follow Wachter (2006) and regress measures of the real risk-free rate on a constant (coefficient α) and an empirical approximation of surplus consumption (coefficent θ). A negative value of θ implies a positive value for b.

Table (7) summarizes the regression estimates. It turns out that the coefficient θ is indistinguishable from zero for five of the six countries under study. The only exception is the UK for which θ is positive and highly significant. Hence, the auxiliary regression suggests that the parameter b should be negative in the calibration for the UK and zero (or very close to zero) for all of the other countries in our sample.

Table 7: Real, risk-free rate and the link to surplus consumption approximation

	CND	GER	JPN	CH	UK	US
α	0.0028	0.0032	-0.0000	-0.0007	-0.0030	-0.0030
(s.e.)	(0.0032)	(0.0016)	(0.0008)	(0.0016)	(0.0008)	(0.0015)
[t-stat]	[0.89]	[2.06]	[-0.02]	[-0.42]	[-3.78]	[-2.00]
θ	-0.0291	-0.1268	0.0150	0.0557	0.1281	0.0341
(s.e.)	(0.0421)	(0.1024)	(0.0194)	(0.0728)	(0.0115)	(0.0215)
[t-stat]	[-0.69]	[-1.24]	[0.77]	[0.77]	]11.18]	[1.59]

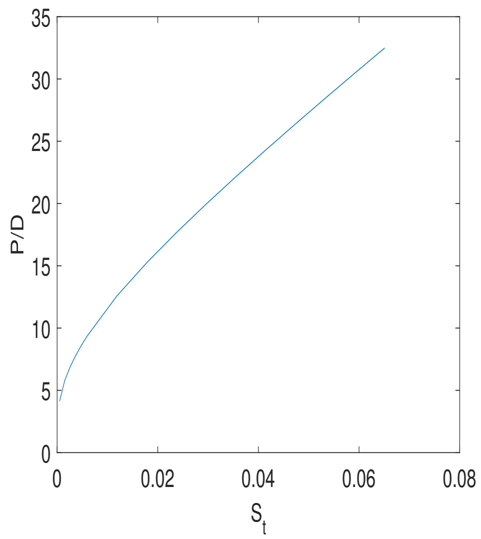
Notes: This Table presents estimations from the following regression $r^{real}_{f,t+1} = \alpha + \theta \sum_{j=1}^{40} \phi^j \Delta c_{t-j} + e_{t+1}$, in which $r^{real}_{f,t+1}$ denotes the empirical measure of the real risk-free rate (three-month nominal interest rate minus realized quarterly inflation) and $\sum_{j=1}^{40} \phi^j \Delta c_{t-j}$, the 40-quarter moving average of past consumption growth represents an empirical approximation to the surplus consumption (Wachter, 2006). The standard errors are adjusted for serial correlation and heteroskedasticity. The sample period ranges from the first quarter of 1988 to the fourth quarter of 2019.

C Country details of model solutions

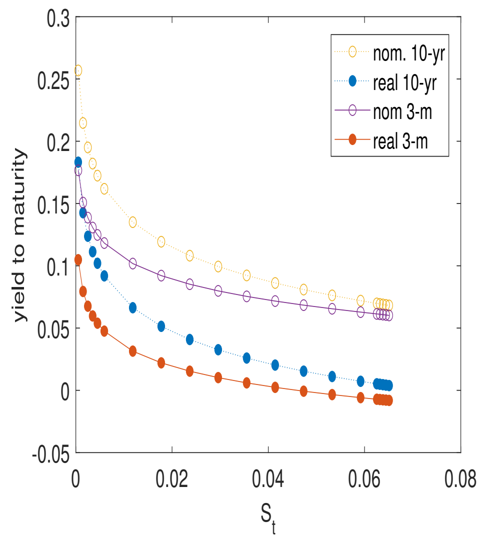
This section graphically summarizes the general model solutions for all of our six sample countries. In general, we find that price-consumption ratios increase with rising surplus consumption. This finding is in line with Campbell and Cochrane (1999). Similar to the US evidence for the period from 1952 to 2004 in Wachter (2006), the model calibrations give nominal yields that lie above real yields. Japan is a special case, in the sense that nominal yields are very close to real yields. Moreover, we find that long-term yields are more sensitive to variation in surplus consumption than short-term interest rates. Different inflation scenarios corroborate these findings.

C.1 Canada

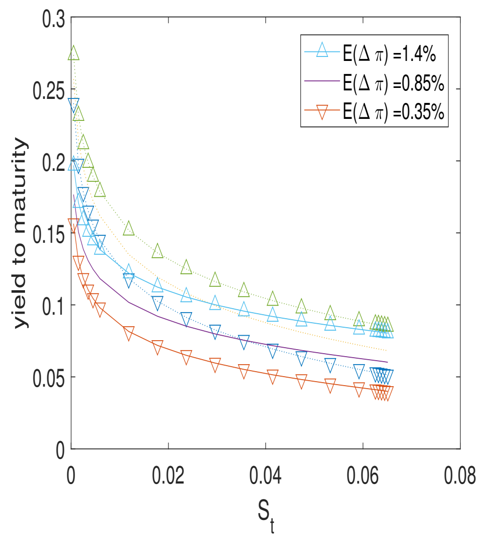
Figure 9: Model solutions: CND



(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption

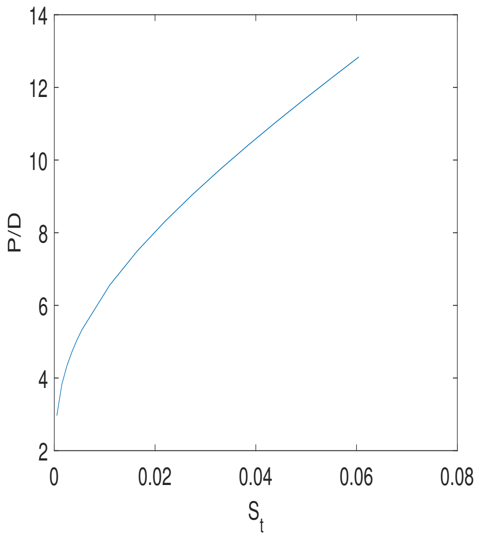


(c) Nominal bond yields, surplus consumption and different inflation scenarios

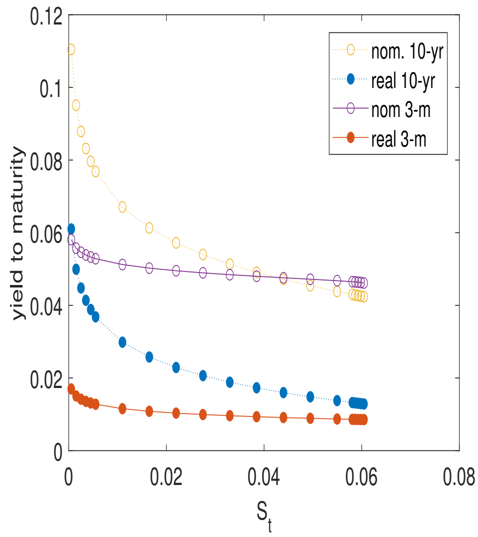
C.2 Germany

Figure 10: Model solutions: GER

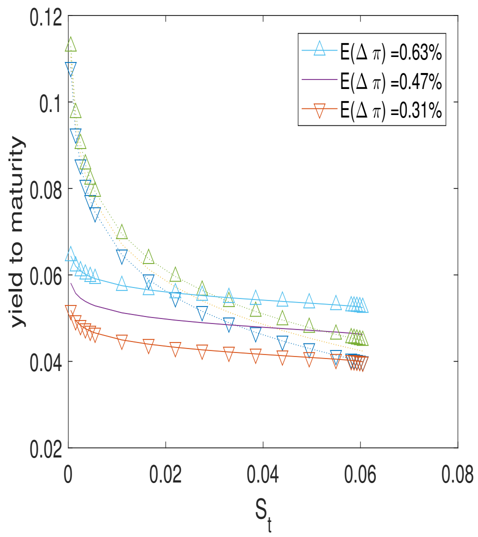
(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption



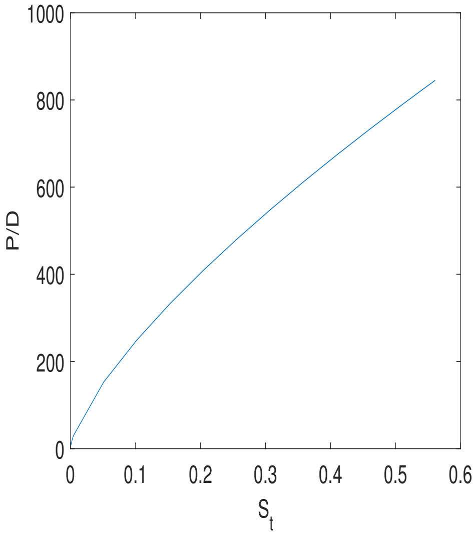
(c) Nominal bond yields, surplus consumption and different inflation scenarios



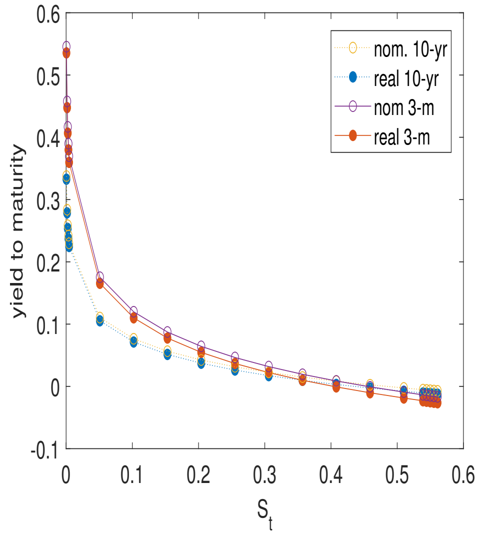
C.3 Japan

Figure 11: Model solutions: JPN

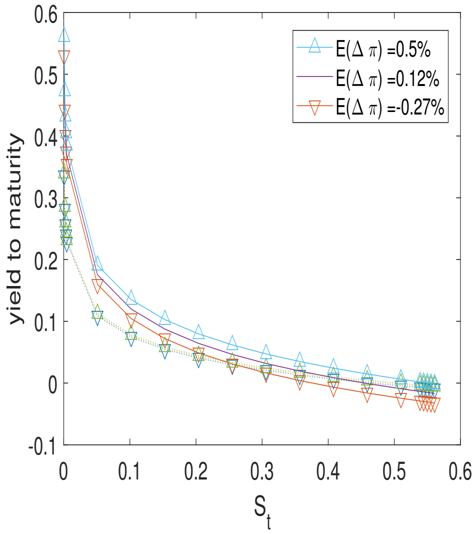
(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption



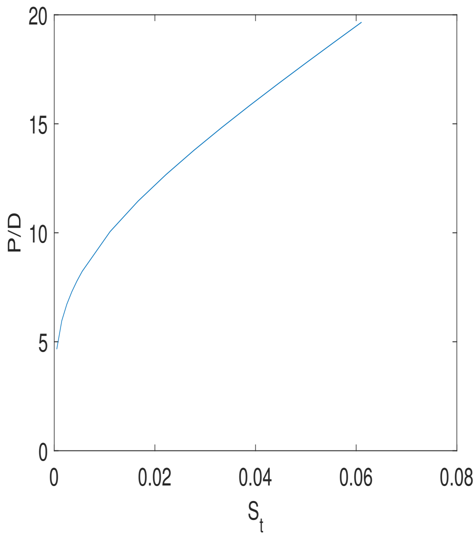
(c) Nominal bond yields, surplus consumption and different inflation scenarios



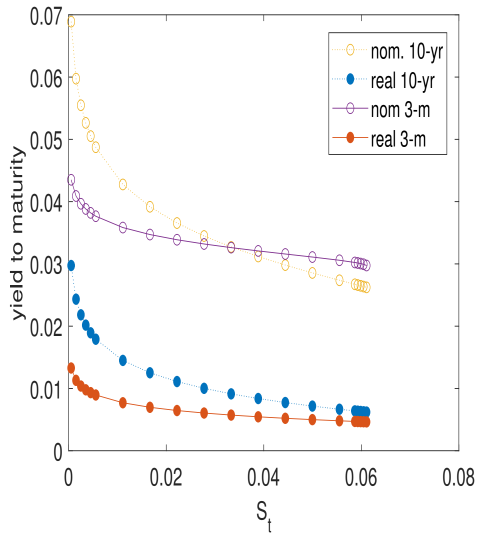
C.4 Switzerland

Figure 12: Model solutions: CH

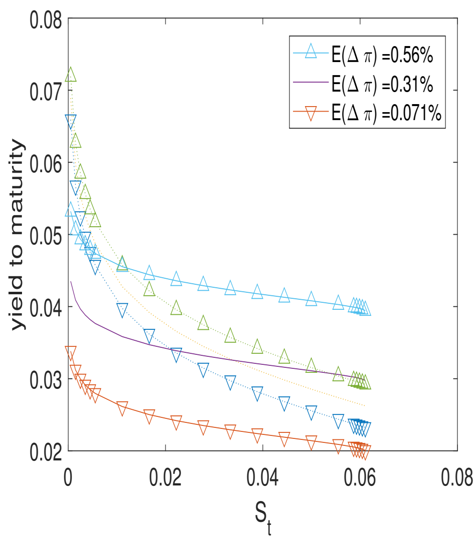
(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption



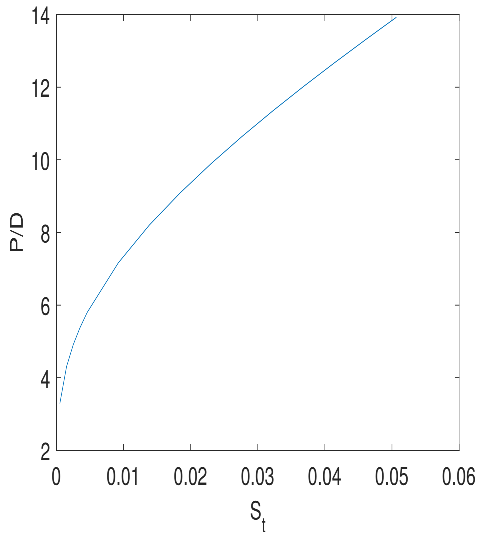
(c) Nominal bond yields, surplus consumption and different inflation scenarios



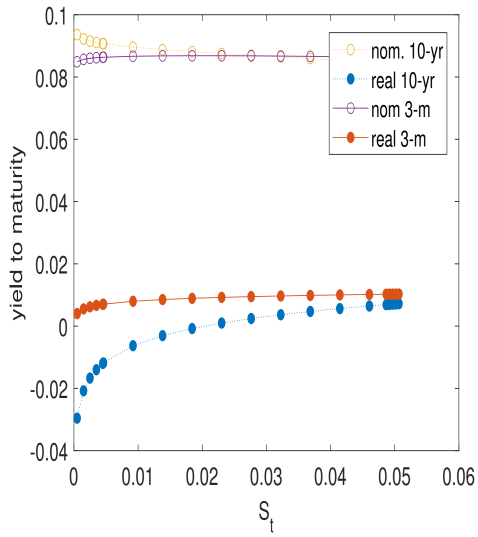
C.5 United Kingdom

Figure 13: Model solutions: UK

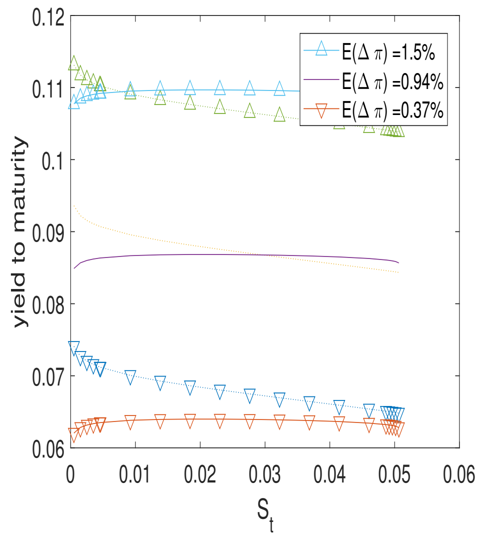
(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption



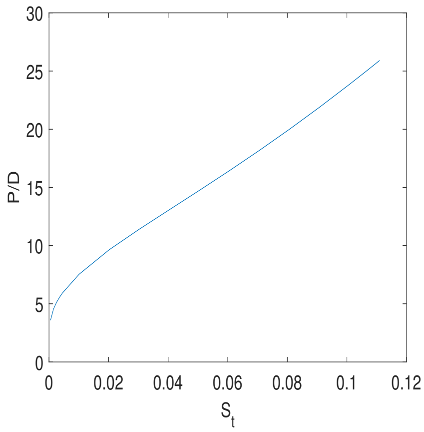
(c) Nominal bond yields, surplus consumption and different inflation scenarios



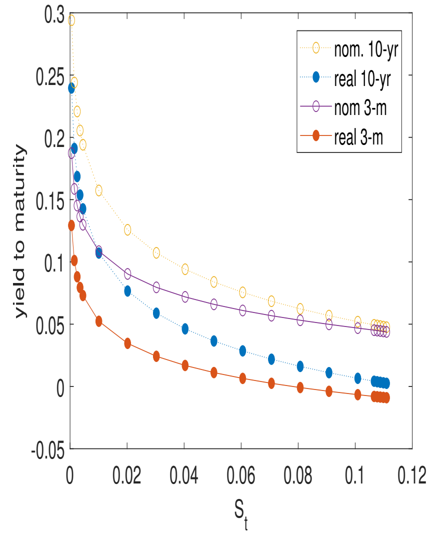
C.6 United States

Figure 14: Model solutions: US

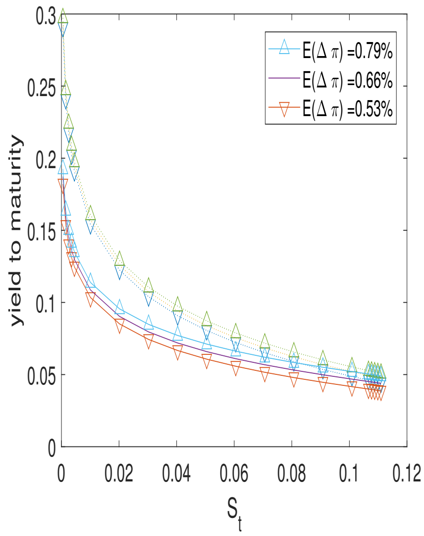
(a) P/D as a function of surplus consumption



(b) Nominal and real bond yields as a function of surplus consumption



(c) Nominal bond yields, surplus consumption and different inflation scenarios



D Test of the expectation hypothesis: Campbell-Shiller regressions

Since Fama and Bliss (1987) and Campbell and Shiller (1991), there is ample, international evidence for the empirical failure of the expectations hypothesis of the term structure of interest rates. According to the expectations hypothesis, long-term bond yields reflect only expected short-term interest rates. Hence, spreads between yields on long-term and short-term bonds should be constant and excess returns on bonds are unpredictable.

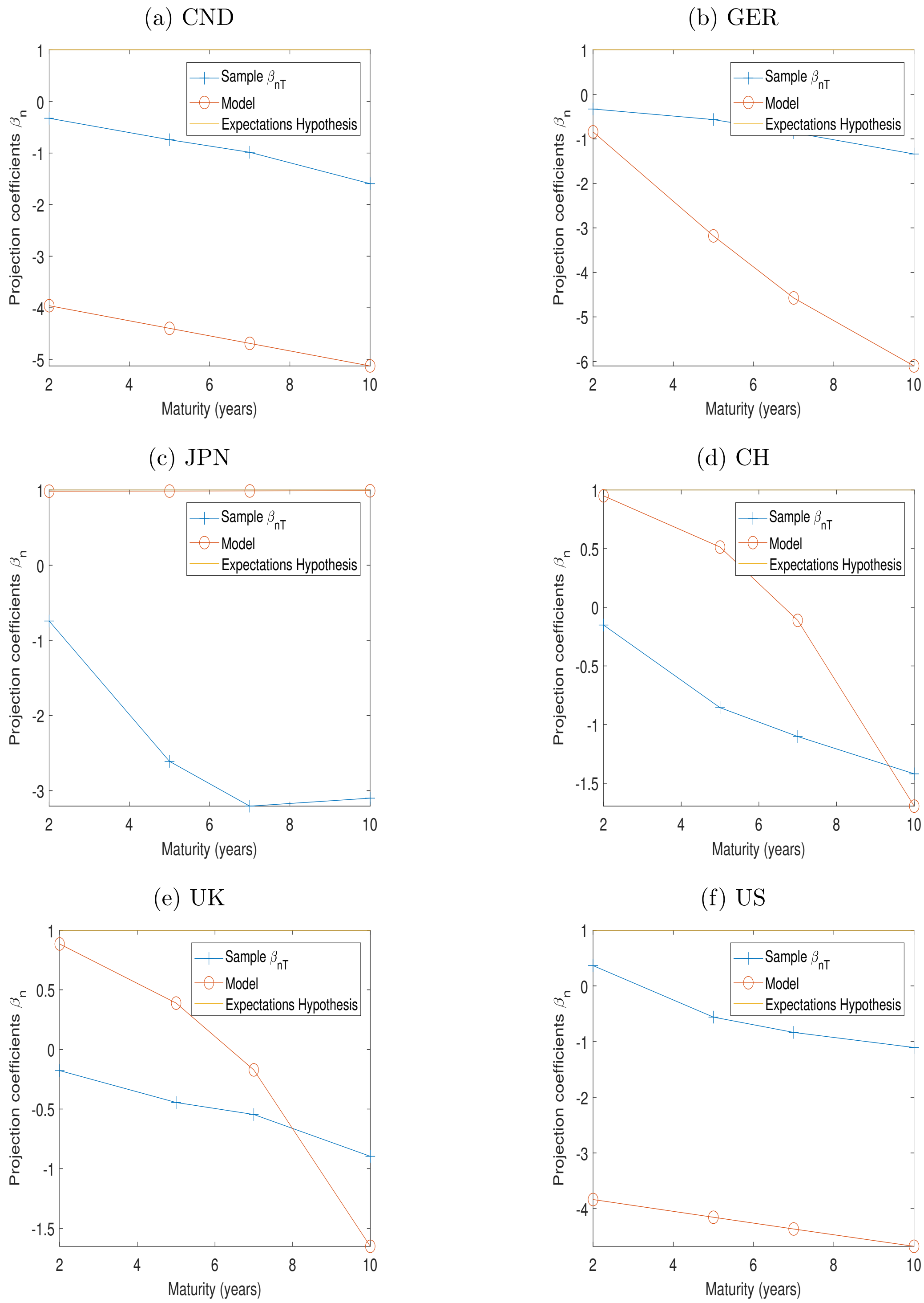
To assess whether the habit model provides a realistic description of time variation in nominal bond yields, we run the Campbell and Shiller (1991) regression

$$y_{n-1,t+1} - y_{n,t} = \alpha + \beta^n \frac{1}{n-1}(y_{n,t} - y_{1,t}) + \varepsilon_{t+1} \tag{19}$$

with actual bond yields for each country under study and with the artificial data generated from the model for each country. If the expectations hypothesis held, the estimates of β^m should be equal to one and long-term bond yields reflect only expected short-term interest rates. In this case, risk premia (whatever their source) play no role in explaining long-term bond yields.

Figure (15) graphically summarizes the outcomes of regression (19). In the data, the coefficients β^m fall with increasing maturity of the bonds and are usually below one. This reflects the failure of the expectations hypothesis. The Campbell-Shiller regressions with model-generated bond yields exhibit a similar pattern. Qualitatively, the bond yields implied by the habit model reflect the failure of the expectations hypothesis in the data. Not too surprisingly, Japan is the exception in this respect. The model does not only produce a flat average yield curve but also time variation in bond yields that is in line with the expectations hypothesis.

Figure 15: Testing the expectations hypothesis: Campbell-Shiller regression coefficients



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