RFS Advance Access published November 3, 2016

Are Stocks Real Assets? Sticky Discount Rates in Stock Markets

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Local stock markets adjust sluggishly to changes in local inflation. When the local rate of inflation increases, local investors subsequently earn lower real returns on local stocks, but not on local bonds or foreign stocks, suggesting that local stock market investors use sticky long-run nominal discount rates that are too low when inflation increases because they are slow to update the inflation expectations in discount rates. Small amounts of stickiness in inflation expectations suffice to match the real stock return predictability induced by inflation in the data. We also consider other explanations, such as nominal cash flow extrapolation. (*JEL* E430, G120, G150)

Received September 14, 2015; editorial decision June 30, 2016 by Editor Stefan Nagel.

Local stock market investors seem slow to adjust nominal discount rates in response to news about the future path of local inflation. The nominal returns on a country's value-weighted stock market index do not increase after a country-specific increase in past inflation. As a result, country-specific inflation lowers local real stock returns roughly by the deviation of that country's rate of inflation from the global average. Bonds are better expected inflation hedges than stocks at short maturities. To emphasize the differences across asset classes, Figure 1 plots nominal and real returns against realized inflation for the 5 quintiles

First version: March 2014. We are especially grateful to the editor, Stefan Nagel, and an anonymous referee for helping us to improve our paper. Robert Richmond and Zhengyang Jiang provided outstanding research assistance. We would like to thank seminar participants at the University of Michigan Ross School of Business, Wharton, the Stanford-Berkeley joint Finance seminar, the San Francisco Federal Reserve Bank, the Federal Reserve Board of Governors, and AQR, as well as Daniel Andrei, Michael Bauer, Jonathan Berk, Kobi Boudoukh, Martijn Boons, Mike Chernov, Jordan Brooks, Barney Hartman-Glaeser, Peter DeMarzo, Ben Hebert, Johnny Kang, John Liew, Monika Piazzesi, Dongho Song, Martin Schneider, Aswhin Thapar, and Michael Weber for helpful comments. This research is partly funded by AQR Capital Management. Supplementary data can be found on *The Review of Financial Studies* web site. Send correspondence to Hanno Lustig, Stanford GSB, 655 Knight Way, Stanford, CA 94305. E-mail: hlustig@stanford.edu.

doi:10.1093/rfs/hhw072

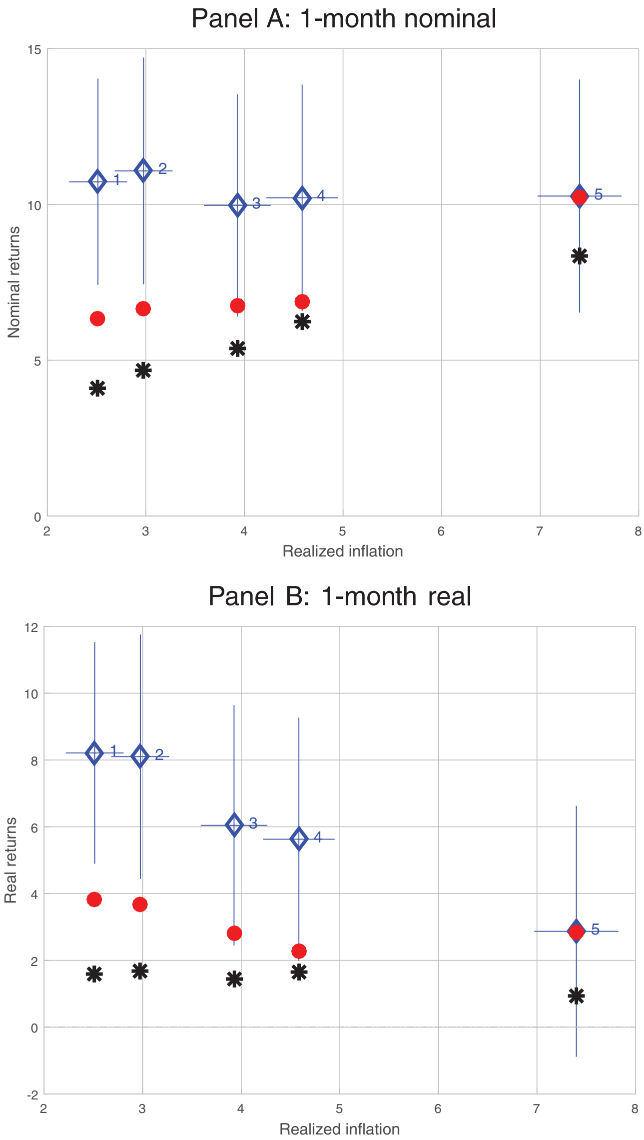

Figure 1
Realized inflation and asset returns for lagged-inflation-sorted portfolios
The figure plots the time-series average of log nominal (real) returns (annualized) against the time-series average of log inflation (annualized) in the left (right) panel at the 1-month horizon for portfolios sorted by the 1-month lagged year-over-year inflation rate ($\pi_{t-12,t}$). The left panel plots nominal returns. The right panel plots real returns. We plot stock returns ("diamonds"), bond returns ("circles"), and returns on T-bills ("stars"). The lines denote two standard error bands. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with nine countries in 1950, and ends with thirty countries in 2012.

of countries sorted by lagged inflation. We consider stocks, bonds and T-bills. Countries with higher lagged inflation do experience higher "circles" and "stars") clearly increase from the first to the fifth quintile. As a result, nominal returns on different asset classes are compressed by inflation. These effects persist over time. Real stock returns, shown in Panel B, decline almost one for one with realized inflation.

The pass-through of locally expected inflation to nominal discount rates used by local stock market investors is slow and incomplete, but there is less evidence of nominal stickiness in T-bill and bond markets after changes in inflation. The nominal returns on local short-term and long-term government bonds respond much faster to changes in inflation.[1] So do exchange rates. As a result, an increase in the local rate of expected inflation shrinks the local equity premium over bills and bonds, but not the equity premium on a basket of foreign stocks, because the local currency depreciates.

Our results are not consistent with the standard notion of money illusion (see Modigliani and Cohn 1979): Investors who are subject to money illusion use nominal discount rates to discount real cash flows. Money illusion predicts that stocks are expensive in low inflation environments. We find the opposite result. To understand our findings, we start by assuming that stock investors discount projected nominal cash flows to value equities. Thus, the log p/d ratio can be inferred from the discounted sums of subjective expectations, denoted by $\mathbb{E}^*$, of nominal future cash flows and returns (Campbell and Shiller 1988):

$$pd_t = constant + \mathbb{E}_t^*\left[\sum_{j=1}^{\infty}\rho^{j-1}\Delta d_{t+j}^{\$}\right] - \mathbb{E}_t^*\left[\sum_{j=1}^{\infty}\rho^{j-1} r_{t+j}^{\$}.\right]$$

We explore 3 potential explanations of why the price/dividend ratio is high when expected inflation is higher than usual, leading to lower subsequent expected real returns under the actual measure. First, nominal discount rates $\mathbb{E}_t^* r_{t+j}^{\$}$ do not respond enough to inflation (i.e., sticky nominal discount rates). Second, nominal cash flow forecasts $\mathbb{E}_t^*\Delta d_{t+j}^{\$}$ respond too much to inflation (i.e., nominal cash flow extrapolation). Third, there is no difference between subjective expectations and actual expectations, and real discount rates $\mathbb{E}_t r_{t+j}^{\$}$ decrease in response to inflation.

First, if stock market investors sluggishly adjust to new information when setting long-run nominal discount rates, then the rates overweight long-run, historical inflation and underweight current inflation: Nominal discount rates are sticky. When inflation is coming down, investors use a nominal discount rate that is too high and hence underprice stocks. For sticky discount rates to explain our findings, the inflation expectation in nominal discount rates need

[1] Our cross-country findings are the cross-sectional analogue of the well-known Fama and Schwert (1977) time-series results for the United States.

to be stickier than those embedded in firm-level cash flow forecasts. Given the large ratio of firm-level cash flow to inflation variance, it is natural that stock investors with a limited capacity to process information would update firm-level nominal cash flow forecasts more frequently than economy-wide inflation forecasts in discount rates. Similarly, Maćkowiak and Wiederholt (2009) argue that firms setting prices pay more attention to idiosyncratic than aggregate shocks when idiosyncratic shocks are more volatile, while Maćkowiak, Moench, and Wiederholt (2009) confirm that prices respond faster to sectoral than to aggregate shocks.[2] We argue that the same holds for investors pricing stocks: investors respond faster to firm-level price shocks on the cash flow side than to aggregate discount rate shocks.

Consistent with the sticky discount rate hypothesis, we find that the difference in real stocks returns between the lowest and highest inflation quintile countries is larger in countries which have only recently experienced high/low inflation; the inter-quintile difference also increases when inflation increases in the high inflation countries, relative to the rate of inflation in the low inflation countries. In addition, we find a large decrease in the real stock return spread between low- and high-inflation countries toward the end of the 1970s and during the 1980s, when information stickiness was on decline in the United States. As inflation volatility increased during the seventies, Coibion and Gorodnichenko (2015) find that information rigidity among United States. professional forecasters declines, and subsequently increases again during the Great Moderation of the 1990s. As predicted by theories of rational inattention, agents reallocate resources towards inflation forecasting when inflation is high and volatile. In our sample, we find no evidence of stickiness in nominal stock returns in those countries with the most volatile inflation history.

Seminal work by Mankiw and Reis (2002) and Sims (2003) has explored the implications of information rigidities in macroeconomics. Coibion and Gorodnichenko (2015) find direct evidence in inflation surveys that supports the sticky information hypothesis; average survey forecast errors are forecastable, which is consistent with the predictions of sticky information models. We find that the inflation expectations of local stock market investors seem slow to adjust to new information, at least substantially slower than those of bond and currency market investors. Given that inflation is not one of the main drivers of stock return variation, but it is for bonds and currencies, this finding may reflect rational inattention: Investors specialized in stock valuation may decide not to continuously monitor inflation, allocating limited bandwidth elsewhere, while bond and currency market investors do. Bacchetta, Mertens, and van Wincoop (2009) and Piazzesi and Schneider (2009b) connect forecast errors in survey forecasts to return predictability in FX and bond markets. Our findings suggest

2 Others have argued that investors may choose to be rationally inattentive in some settings: In a model with information constraints, Kacperczyk, Van Nieuwerburgh, and Veldkamp (2013) argue that mutual fund managers rationally reallocate their attention to idiosyncratic instead of aggregate shocks during expansions.

that inflation forecast errors impute return predictability to stocks, but less so for bonds and currencies.[3]

In a version of the Mankiw and Reis (2002) model of sticky information, we show that lagged inflation predicts lower real stock returns in the future. As inflation increases, investors are slow to update their nominal discount rates, leading to high current valuations and low subsequent real stock returns. Even small departures from rational inflation expectations deliver substantial real stock return predictability that is quantitatively similar to that in the data: Small mistakes have large effects because stocks are high-duration assets. Provided that inflation is sufficiently persistent, the model matches the return predictability in the data if 10% of investors fail to adjust the discount rate in any given year.

However, we do not find evidence that positive inflation surprises instantaneously increase stock market valuations, as predicted by the sticky discount rate hypothesis. This could be due to time aggregation: Our sticky information model predicts that this increase is immediately reversed after the release of inflation news as agents start to update their inflation expectations.

Second, an alternative explanation would be an over-reaction on the nominal cash flow side, induced by extrapolation of nominal cash flows in response to inflation news. This mechanism predicts that long-term earnings forecasts are too high in high inflation countries. We analyze long-term earnings forecast to test the extrapolation hypothesis, and we do not find significant evidence that long-term earnings forecasts are systematically too high in high inflation countries. Barberis, Shleifer, and Vishny (1998), Fuster, Hebert, and Laibson (2011); and Hirshleifer and Yu (2013) have studied asset pricing models in which investors extrapolate fundamentals. In addition, we do find evidence of nominal rigidities in nominal bond returns, albeit smaller than in the case of stocks, which obviously cannot be explained by cash flow extrapolation. Nevertheless, we cannot exclude the possibility that extrapolation plays a role.

Third, we explore explanations within the rational expectations paradigm. In a standard neoclassical asset pricing model with constant real discount rates and perfectly rational agents, local stocks are perfect hedges against increases in the cost of the local consumption basket, because they are claims to real cash flows that are produced domestically.[4] But real discount rates applied by stock

[3] In addition, career concerns give bond managers a strong incentive to spend some bandwidth on monitoring inflation, because inflation forecast errors would differentially effect bond portfolios. Not so for stock portfolios. Our evidence is also consistent with the findings of other researchers who study the effect of macroeconomic announcements on asset prices: Rigobon and Sack (2006) document large, instantaneous effects of monetary policy innovations on yields in bond markets, and smaller, muted effects on valuations in stock markets.

[4] While sticky prices in product markets can explain incomplete pass-through of surprise inflation to nominal stock returns (see Gorodnichenko and Weber [2013] for evidence on the effects of sticky prices in stock markets around Fed announcements), they cannot account for incomplete pass-through of expected inflation.

investors can vary over time. If the local risk price is lower in higher-than-average inflation countries,[5] a negative relation between expected inflation and real stock returns emerges. In this view of our empirical findings, local investors fully expect to earn lower returns on stocks when local inflation is higher than in other countries, because that is when their appetite for stock market risk is highest.

We cannot rule out time variation in real discount rates as an explanation of our findings without committing to a fully specified Dynamic Asset Pricing Model. However, this explanation faces 3 challenges. First, in the United States and around the developed world, the covariance between stock and bond returns is robustly positive for most of the sample, suggesting that higher inflation expectations increase the real discount rates on stocks. Second, the negative cross-sectional relation between real returns and expected inflation weakens at the end of the 1990s, when the covariance between bond returns and stock returns turns negative in the United States (see Baele, Bekaert, and Inghelbrecht 2010; Campbell, Sunderam, and Viceira 2013) and all around the developed world. This is exactly when countries with abnormally low inflation should yield the highest real returns in a model with time-varying discount rates.[6] Third, the time-varying discount rate hypothesis is hard to reconcile with the negative cross-sectional relation between realized real stock returns and inflation surprises that we document. All else equal, a decrease in local inflation should increase discount rates and hence produce lower real returns. We find the opposite.

Thus, our results present a challenge to leading asset pricing models which impute rational inflation expectations to its agents. In a rational expectation model, the agents inside the model possess knowledge that real-world investors do not have (e.g., Sargent 2002): Real-world investors need to solve a complicated inference problem to develop inflation expectations. Different classes of investors may respond differently to this challenge. Recently, a number of authors have documented evidence of heterogeneity in inflation expectations across households that is shaped by their personal experiences (see Piazzesi and Schneider 2009a; Malmendier and Nagel 2015).

A large body of empirical literature on inflation hedging documents that real stock returns decrease after countries experience higher than average inflation for that country (see the work by Lintner 1975; Jaffe and Mandelker 1976; Fama and Schwert 1977; Solnik 1983; Erb, Harvey, and Viskanta 1995; Bekaert and Wang 2010). In the time series, a country's local inflation rate is a weak predictor of real, local stock returns. We find that past inflation is a strong predictor of

5 This is a cross-sectional version of Fama (1981)'s proxy hypothesis; inflation proxies other macro-economic variables that affect how investors discount cash flows. Geske and Roll (1983) develop a fiscal version of this argument.

6 Campbell, Pflueger, and Viceira (2013) and David and Veronesi (2014) develop explanations for the time variation in the stock-bond correlation. Song (2014) reconciles the upward sloping nominal yield curve with a negative stock-bond correlation in a regime switching model.

real stock returns in the cross-section of countries: real local stock returns are significantly higher in countries with past inflation that is currently lower than the global average, simply because nominal local stock returns do not respond to news about the future path of inflation at short horizons.

1. Decomposing the Incomplete Pass-Through of Inflation to Stock Returns

We will establish that nominal stock returns seem sluggish in responding to changes in local inflation. This section briefly reviews all potential explanations. We use \$ to denote variables expressed in nominal terms. We consider the cum-dividend return on a stock, expressed in dollars:

$$R^{\$}_{t+1} = \frac{P^{\$}_{t+1} + D^{\$}_{t+1}}{P^{\$}_t} = \frac{\frac{D^{\$}_{t+1}}{D^{\$}_t}(1+PD_{t+1})}{PD_t}.$$

We use pd_t to denote the log price-dividend ratio: $pd_t = p^{\$}_t - d^{\$}_t = \log(\frac{P^{\$}_t}{D^{\$}_t})$, where price is measured at the end of the period and the dividend flow is over the corresponding period. Log-linearization of the nominal return equation around the mean log price/dividend ratio delivers the following expression for log dollar returns denoted $r^{\$}$ (see Campbell and Shiller 1988):

$$r^{\$}_{t+1} = \Delta d^{\$}_{t+1} + \rho pd_{t+1} + k - pd_t,$$

with a linearization coefficient ρ that depends on the mean of the log price/dividend ratio pd: $\rho = \frac{e^{pd}}{e^{pd}+1} < 1$. By iterating forward on the linearized nominal return equation and imposing a no-bubble condition, $\lim_{j,\infty} \rho^j pd_{t+j} = 0$, we obtain the following expression for the log price/dividend ratio as a function of nominal cash flows and discount rates:

$$pd_t \equiv constant + \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d^{\$}_{t+j}\right] - \left[\sum_{j=1}^{\infty} \rho^{j-1} r^{\$}_{t+j}\right]. \quad (1)$$

This expression has to hold for all sample paths. We assume that investors use this nominal pricing equation to value stocks, which gives rise to the following expectation under the subjective measure:

$$pd_t = constant + \mathbb{E}^*_t \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d^{\$}_{t+j}\right] - \mathbb{E}^*_t \left[\sum_{j=1}^{\infty} \rho^{j-1} r^{\$}_{t+j}\right]. \quad (2)$$

We explore 3 potential explanations. First, nominal discount rates $\mathbb{E}^*_t r^{\$}_{t+j}$ do not respond enough to inflation (i.e., sticky discount rates). As a result, inflation increases the price-dividend ratio. The present-value relation also holds under the true measure for real returns and real dividend growth:

$$pd_t = constant + \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}\Delta d_{t+j}\right] - \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}\right]. \tag{3}$$

In this case, the real returns expected under the true measure $\mathbb{E}_t[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}]$, which are estimated by the econometrician, have to decline in response to an increase inflation to accommodate the increase in pd_t; real cash flow growth cannot adjust. Second, nominal cash flow forecasts $\mathbb{E}^*_t \Delta d^{\$}_{t+j}$ respond too much to inflation (i.e., nominal cash flow extrapolation). As before, pd_t increases in response to inflation, and real returns expected under the true measure $\mathbb{E}_t[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}]$ have to decline in response to an increase inflation.

Third, we consider a rational expectations-based explanation. Rational expectations rule out differences between subjective expectations and expectations under the actual measure. These explanations require that $\mathbb{E}_t[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}.]$ declines when inflation increases. In this case, the average real returns measured by the econometrician coincide with the investors' expected returns.

2. Inflation and Returns Across Countries

We study a panel of countries to learn about the relation between stock returns and inflation.

2.1 Data

We collect data from Global Financial Data to construct a panel of developed countries and emerging market countries. For each of these countries, we gather returns on a value-weighted stock market index, the Consumer Price Index, the return on a 10-year government bond index, as well as the T-bill returns. The sample starts in 1950 and ends in 2012. We supplement the GFD stock return data with MSCI stock index data when possible. The 10-year government bond indices were also constructed by GFD. The total return bond indices are based upon the yields on 10-year government bonds unless otherwise indicated.[7]

The comprehensive list of countries for which we have stock return data, T-bill data and inflation data are in the Online Appendix. We refer to this as the stocks-only panel. The sample starts with 10 countries in 1950 and ends with 46 countries in 2012. The limited panel of all countries for which we have

[7] Where no 10-year bond was available, the bond closest to a 10-year bond was used. For each country, GFD provides detailed information on the construction of the bond. The Online Appendix provides a list of country codes.

stock, bond as well as T-bill and inflation data starts with only 10 countries in 1950, and ends with 31 countries in 2012. We refer to this as the bonds/stocks panel.

Throughout the paper, we report moments of log returns, simply because that renders the relation between nominal and real returns additive. $\Pi_{t-k,t} = \frac{CPI_t}{CPI_{t-k}}$ is the inflation rate over k periods. Lowercase symbols denote logs. $\pi_{t-k,t}$ is the log of the inflation rate over k periods. $R^{\$}_{t-k,t}$ is the nominal gross return on a risky asset. $r^{\$}_{t-k,t}$ is the log of the gross returns in dollars. $Rx_{t-k,t} = \frac{R_{t-k,t}}{R^f_{t-k,t}}$ is the multiplicative excess return on the risky asset. $rx_{t-k,t} = \log R_{t-k,t} - \log R^f_{t-k,t}$ is the log excess return. Finally, $R^{\star}_{t-k,t} = \frac{R_{t-k,t}}{\Pi_{t-k,t}}$ is the real return on the asset in local units of consumption, while $r^{\star}_{t-k,t} = \log R_{t-k,t} - \log \Pi_{t-k,t}$ is the log of the real return in local units of consumption. $R^{£}_{t-k,t}$ is the gross return in local currency.

2.2 Country-level evidence on inflation and returns

While most of the literature on inflation hedging and stocks focuses on inflation in its entirety, our paper shifts attention to the country-specific component of inflation. This country-specific component is economically relevant. To establish the country-level facts, Table 1 lists the key moments of log inflation and log returns. The first column is the cross-sectional mean of the time-series average of inflation (returns). The second column reports the cross-sectional standard deviation. For each country, the time series average is computed over the sample that starts when that country enters our panel. We consider investment horizons ranging from 1 month to 12 months. At the 1-month horizon, the average annualized rate of inflation in our sample is 4.15%, while the cross-sectional standard deviation of annualized average inflation is 1.9%. We also report the R^2 in a regression of inflation on average global inflation. Global inflation accounts for 23% (1-month horizon) to 51% (12-month horizon) of the total variation in inflation for the average country in the sample. This confirms that there is a large common component in inflation (see, e.g., Henriksen, Kydland, and Šustek 2013). At annual frequencies, average global inflation accounts for up to half of country-level variation in inflation. We focus on the country-specific half of inflation variation, because we can develop sharper statistical inference about the response of asset markets to the country-specific component in inflation.

Finally, Table 1 also report real log returns and log excess returns. The average real log return on stocks is 4.75% *per annum* at the 1-month horizon. The average equity premium is only 3.11% *per annum* at the 1-month horizon. This is mostly due to the fact that many countries enter the sample in the last 2 decades. Importantly, there is no statistically significant relation between average inflation and average real stock returns at country level.

Table 1
Country-level evidence on inflation and returns

Horizon		1-month		3-month		12-month	
Moments		X-mean	X-std	X-mean	X-std	X-mean	X-std
Panel A: Log inflation $\pi_{t,t+k}$							
Inflation	Mean	4.15	1.90	4.14	1.88	4.10	1.84
	Std	2.04	0.68	2.38	0.80	3.15	1.33
	R^2	0.23	0.12	0.35	0.17	0.51	0.22
Panel B: Nominal-log returns in local currency $r^{£}_{t,t+k}$							
T-bills	Mean	5.79	2.21	5.78	2.20	5.78	2.15
	Std	1.07	0.61	1.83	1.02	3.49	1.81
Bonds	Mean	8.30	2.93	8.29	2.94	8.13	2.80
	Std	7.88	5.41	8.21	4.86	8.81	4.90
Stocks	Mean	8.91	3.55	8.98	3.58	8.94	3.68
	Std	21.53	5.12	23.31	5.46	25.17	5.92
Panel C: Real-log returns in local units of consumption $r^{*}_{t,t+k}$							
T-bills	Mean	1.64	1.10	1.64	1.09	1.68	1.12
	Std	2.00	0.66	2.28	0.62	3.02	0.83
Bonds	Mean	4.15	2.14	4.14	2.17	4.03	2.11
	Std	8.24	5.30	8.72	4.79	9.35	4.80
Stocks	Mean	4.75	2.59	4.84	2.57	4.84	2.81
	Std	21.68	5.14	23.53	5.49	25.71	5.87
Panel D: Log-excess returns in local currency $rx^{£}_{t,t+k}$							
Bonds/T-bills	Mean	2.51	1.77	2.50	1.78	2.35	1.65
	SR	0.36	0.18	0.34	0.18	0.32	0.20
Stocks/T-bills	Mean	3.11	2.89	3.19	2.85	3.16	3.04
	SR	0.16	0.15	0.15	0.14	0.14	0.13

This table reports the cross-sectional mean/standard deviation of country-level time-series averages of inflation and returns. Annualized log k-month returns and inflation. The countries are sorted by year-over-year inflation realized at month $t-1$ ($\pi_{t-12,t}$). The sample is 1950-2012. The data is monthly. This table also reports the R^2 in a regression of inflation on average global inflation. The Bonds/Stocks panel includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with only 10 countries in 1950, and ends with 31 countries in 2012.

3. Incomplete Pass-Through of Expected Inflation to Asset Markets

An *asset* is commonly defined as a perfect inflation hedge if its returns move one for one with expected inflation and inflation surprises. This section examines the cross-country relation between the country-specific component of expected inflation and stock, bond, and T-bill returns in the cross-section.

3.1 The cross-section of expected inflation and returns

In their seminal paper, Fama and Schwert (1977) define an *asset* as a perfect inflation hedge if the asset has betas of unity in a multivariate time-series regression of returns on expected and unexpected inflation. Fama and Schwert (1977) conclude that United States stocks are ineffective hedges against shocks to overall inflation, in line with the earlier results by Lintner (1975) and Jaffe and Mandelker (1976). These results have been confirmed in international data see, e.g., Solnik 1983, Erb, Harvey, and Viskanta 1995). Bekaert and Wang (2010) finds similar results in international data, but, the statistical evidence is weak.

To summarize, the consensus view is that the time-series relation between nominal stock returns and inflation innovations is statistically weak and typically negative, at least at short horizons. When forecasting returns with inflation in a time-series regression, one needs an estimate of the average rate of inflation of that country. A negative slope coefficient means that real returns are lower when inflation is higher than average for that country. This country-specific average is hard to estimate, possibly because it varies over time. Instead, we investigate the cross-sectional relation between expected inflation and asset returns by sorting countries into portfolios. This portfolio sorting is equivalent to running cross-sectional non-linear regressions of returns on expected inflation and inflation innovations, one for each time observation, without restrictions on how the coefficients change over time. A negative slope coefficient means that real returns are lower when inflation is higher than the global average at that time, irrespective of that country's average rate of inflation.[8]

We consider an AR(1) process for inflation in these countries:

$$\pi_t^i = (1-\phi)\theta + \phi\pi_{t-1}^i + u_{t-1}^i, \tag{4}$$

where $-1 < \phi < 1$ is the AR(1) coefficient and θ is the unconditional mean. We use lagged inflation as a measure of expected inflation in the cross-section. If countries share the same $\phi < 1$ and θ parameters, then lagged year-over-year inflation is a perfect measure of short-run inflation expectations. Alternatively, if inflation is a unit root process with $\phi = 1$ and $\theta = 0$, then lagged inflation is always the best forecast. We use realized inflation between $t-12$ and t, denoted $\pi_{t-12,t}$, as a measure of expected inflation at t. We use year-over-year inflation to eliminate issues of seasonality in the CPI. Adding an additional 1-month lag (i.e., using $\pi_{t-13,t-1}$) has no effect on the results.

3.1.1 Sorting by lagged inflation. We sort countries into quintiles by lagged inflation. We start with the sample of countries for which we have bond and stock returns, as well as inflation. The sample starts out with 10 countries in 1950 (Germany, Italy, the United States, France, Canada, Sweden, Japan, the United Kingdom, Spain, and Australia) and it ends with 31 countries in 2012. Australia and New Zealand only report quarterly CPI data. We simply impute the last quarterly CPI level to the next 2 months in the results reported, but we also checked the robustness of our results when we exclude these two countries.

Figure 2 plots the composition of the portfolios re-sorted by year-over-year inflation at the end of each month over time. There is a lot of variation in the

8 Non-linear cross-sectional regressions do indeed produce similar results to the portfolio sorts, but only if we allow the coefficients to vary over time. We do not need to estimate the country-specific average inflation rate.

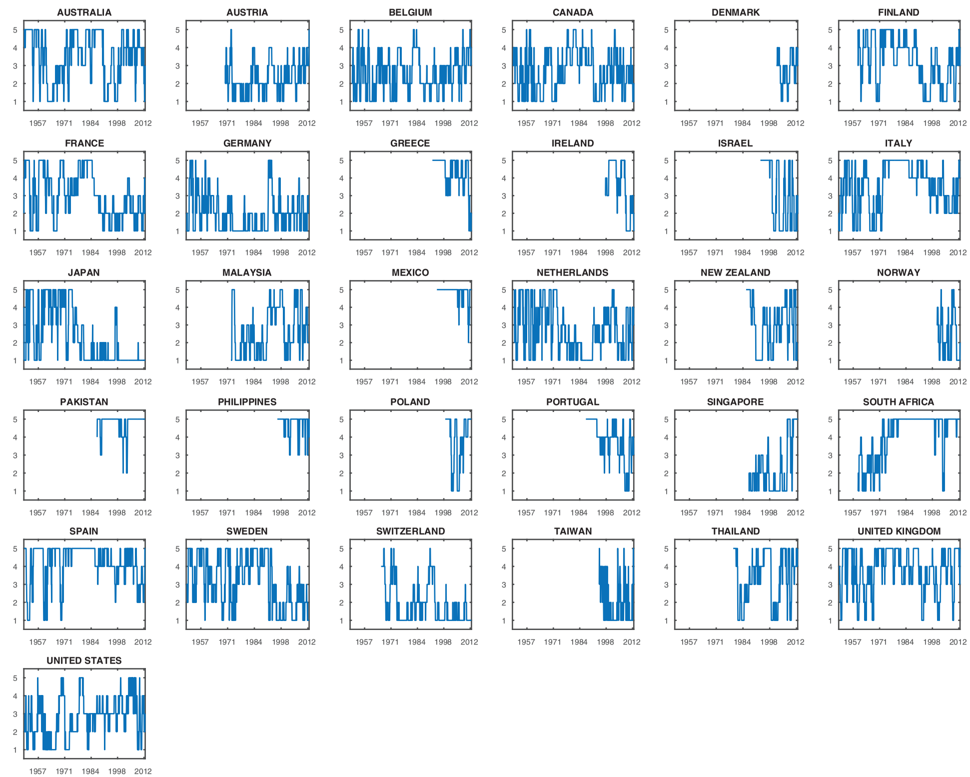

Figure 2
Composition of portfolios sorted by lagged inflation for bonds/stocks panel
The panel plots the composition of portfolios of countries sorted by lagged year-over-year inflation ($\pi_{t-12,t}$) each month at t. The portfolio is on the y-axis. The panel includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with nine countries in 1950, and ends with thirty countries in 2012.

Table 2
Lagged-inflation-sorted portfolios

Horizon		1-month						3-month	12-month
Portfolio		Low	2	3	4	High	High-Low	High-low	High-low
Panel A: Log inflation $\pi_{t,t+k}$									
Sorted	Mean	1.77	2.84	3.90	5.18	8.98	7.21	7.21	7.25
	Std	2.06	2.23	2.59	3.08	4.06	3.03	3.03	3.03
Realized	Mean	2.51	2.98	3.93	4.58	7.40	4.89	4.75	4.28
	Std	1.13	1.09	1.32	1.42	1.67	1.73	2.02	3.20
Panel B: Nominal-log returns in local currency $r^{£}_{t,t+k}$									
T-bills	Mean	4.11	4.67	5.38	6.24	8.34	4.23	4.21	4.08
	S.e.	0.07	0.08	0.10	0.12	0.16	0.14	0.24	0.47
	Std	0.55	0.63	0.76	0.94	1.27	1.10	1.89	3.70
Bonds	Mean	6.35	6.65	6.74	6.87	10.24	3.89	4.02	3.85
	S.e.	0.48	0.53	0.57	0.53	0.54	0.61	0.66	0.90
	Std	3.83	4.13	4.54	4.17	4.25	4.79	5.37	6.58
Stocks	Mean	10.73	11.08	9.97	10.21	10.27	−0.46	−0.41	0.64
	S.e.	1.65	1.82	1.78	1.82	1.87	1.52	1.65	1.73
	Std	13.07	14.46	14.13	14.36	14.76	11.92	12.50	14.42
Panel C: Real-log returns in local units of consumption $r^{*}_{t,t+k}$									
T-bills	Mean	1.60	1.69	1.45	1.65	0.94	−0.66	−0.54	−0.20
	S.e.	0.14	0.15	0.17	0.17	0.21	0.22	0.22	0.33
	Std	1.10	1.08	1.30	1.35	1.61	1.68	1.85	2.59
Bonds	Mean	3.83	3.68	2.82	2.29	2.84	−1.00	−0.72	−0.43
	S.e.	0.52	0.55	0.61	0.58	0.57	0.64	0.68	0.90
	Std	4.11	4.31	4.81	4.54	4.49	5.05	5.57	6.68
Stocks	Mean	8.21	8.10	6.04	5.63	2.87	−5.34	−5.16	−3.64
	S.e.	1.66	1.83	1.80	1.82	1.88	1.53	1.65	1.80
	Std	13.11	14.54	14.27	14.40	14.84	12.05	12.64	14.93
Panel D: Log-excess returns in local currency $rx^{£}_{t,t+k}$									
Bonds/T-bills	Mean	2.24	1.99	1.37	0.63	1.89	−0.34	−0.19	−0.23
	S.e.	0.48	0.53	0.57	0.54	0.51	0.59	0.62	0.79
Stocks/T-bills	Mean	6.61	6.41	4.60	3.97	1.93	−4.69	−4.62	−3.44
	S.e.	1.66	1.83	1.79	1.82	1.88	1.52	1.65	1.79
Stocks/Bonds	Mean	4.38	4.42	3.23	3.34	0.03	−4.35	−4.43	−3.21
	S.e.	1.71	1.85	1.82	1.85	1.84	1.56	1.58	1.74

Time-series averages of annualized log k-month returns on portfolios. The countries are sorted by year-over-year inflation realized at month $t-1$ ($\pi_{t-12,t}$). The portfolios are re-sorted each month. The sample is 1950-2012. The data is monthly. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with only 10 countries in 1950, and ends with 31 countries in 2012. The standard errors, denoted “s.e.”, were generated by bootstrapping 10,000 samples with replacement. “Std” denotes the time series standard deviation.

composition of the portfolios, but at the country-level, there is quite some persistence. For example, the 1-month rank-autocorrelation for the United States is 0.86, but the 1-year rank-autocorrelation is only 0.37. The average 1-month autocorrelation for all countries for which we have data over the entire sample is also 0.81. The median portfolio allocation for the United States. is the middle one.

Table 2 reports results obtained when countries are resorted each month into quintiles based on the lagged annual inflation rate. The standard errors were generated by bootstrapping 10,000 samples from the data. We start with the results at the 1-month horizon. The first panel reports pre-sort annual inflation and subsequently realized inflation over the next month (annualized). During the 12 months preceding the sort, countries in the fifth quintile recorded inflation of 8.98%, while countries in the first quintile recorded a 1.77% rate. The 7.21% spread in lagged inflation ($\pi_{t-12,t}$) translates into a 4.89% spread in realized inflation ($\pi_{t,t+12}$). Hence, lagged inflation is a reliable measure of expected inflation on the part of rational investors. Countries in the last quintile have also experienced inflation that is more than twice as volatile (4.06%) as that in the first quintile (2.06%).

The second panel reports nominal bond and stock returns in local currency ($r^{£}_{t,t+k}$) on these inflation-sorted portfolios. The returns on T-bills increase by 4.23% from the first to the last quintile. While nominal bond returns increase by 3.89% from the first to the last quintile, not enough to keep up with inflation, nominal stock returns actually decrease by 0.46%.

The third panel reports the implications for real bond and stocks returns ($r^{*}_{t,t+k}$). Since we report log returns, the real returns are the nominal returns less the rate of inflation. For example, the average nominal stock return in the first quintile is 10.73%, the realized rate of inflation is 2.51%, and the real rate of return is the difference, 8.21%. Real stock returns decrease monotonically from 8.21% *per annum* to 2.87% *per annum* in the last portfolio, while real bond returns decrease from 3.83% *per annum* to 2.84% *per annum*. Hence, both bonds and stocks are imperfect hedges against expected inflation, but stocks are by far the worse hedges. The spread in real stock returns between quintiles 1 and 5 is 5.34% *per annum* (s.e. of 1.58%). Adding one or two additional lags in realized annual inflation, our sorting variable, does not materially affect these results.

Real T-bill returns are roughly constant across these portfolios. In that sense, sorting by lagged inflation produces very different results from country sorts by nominal interest rates[9] (see Verdelhan 2010), which produce mostly real interest rate variation. Clearly, real interest rate variation is not driving our results.

Finally, the fourth panel in Table 2 reports the excess returns in local currency ($rx^{£}_{t,t+k}$). These local currency excess returns can also be interpreted as the approximate returns earned by currency-hedged foreign investors. As a result of this imperfect hedging by local stocks against expected inflation, the equity premium on local stocks declines from 6.61% to 1.93% as we increase expected inflation by switching from the first to the last quintile. The spread between the extreme quintiles is 4.69% *per annum* (s.e. of 1.53%). We also found that the inter-quintile spread in the equity premium of local stocks over local bonds

[9] Online Appendix F reports results for sorts of countries by nominal interest rates.

is almost as large: 4.35% *per annum*. There is a marked compression of the returns on equities and other asset classes in the highest inflation quintiles.

3.1.2 Sorting by lagged inflation in deviation from average inflation. When countries have different (unconditional) mean rates of inflation (θ in Equation 4), but the same persistence, then it might be more informative to use lagged inflation in deviation from the mean as a measure of expected inflation in the cross-section. The results are as strong when we focus on countries with currently unusually high or low inflation. Table 3 reports the results obtained when we sort by lagged inflation in deviation from that country's 10-year average. The spread in real stock returns at the 1-month horizon between the first and the last quintile is 5.13%. In the highest quintile, we now exclusively have countries who currently experience unusually high inflation, rather than countries that on average have experienced high inflation. Interestingly, bonds also seem slow to respond to the change in inflation, as manifested in the 388 basis points spread. However, this spread is only 247 basis points at the 12-month horizon.

We were conservative in using the 1-month lag of year-over-year inflation. If we adopt an even more conservative approach, and we use the year-over-year inflation rate realized at the end of month $t-3$ to sort countries at the end of month t, to allow investors more time to respond, then we obtain a slightly smaller spread in real stock returns between the first and fifth quintile of 4.75%, while the same spread for bonds is only -1.57% *per annum*.

High-inflation countries do not yield low real returns; only countries with currently abnormally high inflation. When we sort countries by average inflation realized over the past 10 years (our proxy for θ) instead, we do not observe similar patterns. These results are reported in Table A11 in the Online Appendix. Nominal stock returns fully compensate for higher inflation in countries that have experienced high inflation on average. In fact, stocks do slightly better in real terms in countries that have, on average, experienced high inflation over the past decade. The spread in nominal stock returns between the first and the last quintile is 5.34%, compared with a 4.42% difference in realized inflation. Over long periods, inflation expectations have no effect on real stock returns. Hence, we can rule out country-fixed effects as an explanation of our results. Not surprisingly, average inflation has no significant effect on real bond returns either. The inter-quintile range in average nominal bond returns is 4.65%.

3.1.3 Robustness. We have established that the pass-through of expected inflation to nominal stock returns is slow and incomplete. The local component of expected inflation is a powerful predictor of real returns on stocks in the cross-section of countries: When a country's expected inflation rate is higher than the global average, subsequent real returns and excess returns are lower for stocks, but not for bonds. The size of the effect on real stock returns is roughly equal to the rate of inflation, in deviation from the global average. This

Table 3
Lagged-inflation-sorted portfolios

Horizon		1-month						3-month	12-month
Portfolio		Low	2	3	4	High	High-Low	High-low	High-low
Panel A: Log inflation $\pi_{t,t+k}$									
Sorted	Mean	−5.07	−2.01	−0.60	0.39	2.26	7.32	7.32	7.38
	Std	6.76	3.26	2.03	2.06	2.59	6.51	6.51	6.53
Realized	Mean	4.34	3.84	3.89	4.26	5.88	1.54	1.58	1.23
	Std	1.33	1.24	1.24	1.38	1.65	1.85	2.17	3.31
Panel B: Nominal-log returns in local currency $r^{£}_{t,t+k}$									
T-bills	Mean	6.64	5.68	5.37	5.34	6.54	−0.10	−0.08	−0.10
	S.e.	0.13	0.12	0.11	0.11	0.12	0.13	0.22	0.45
	Std	1.03	0.90	0.84	0.86	0.97	1.01	1.72	3.33
Bonds	Mean	9.37	7.38	7.00	7.08	7.02	−2.35	−2.04	−1.24
	S.e.	0.61	0.55	0.52	0.47	0.51	0.66	0.69	0.93
	Std	4.79	4.37	4.08	3.71	4.02	5.23	6.17	6.64
Stocks	Mean	12.96	11.46	9.74	9.64	9.36	3.60	−4.29	−3.17
	S.e.	1.85	1.73	1.76	1.76	1.93	1.66	1.87	2.30
	Std	14.42	13.69	13.98	13.99	15.29	13.00	14.40	16.76
Panel B: Real-log returns in local units of consumption $r^{*}_{t,t+k}$									
T-bills	Mean	2.30	1.84	1.48	1.08	0.66	−1.64	−1.66	−1.33
	S.e.	0.18	0.17	0.16	0.16	0.20	0.24	0.24	0.27
	Std	1.34	1.29	1.21	1.24	1.49	1.69	1.75	2.21
Bonds	Mean	5.03	3.54	3.11	2.82	1.14	−3.88	−3.62	−2.47
	S.e.	0.63	0.58	0.55	0.51	0.55	0.71	0.73	0.97
	Std	4.94	4.59	4.31	4.03	4.36	5.49	6.54	6.72
Stocks	Mean	8.62	7.63	5.85	5.38	3.49	−5.13	−5.87	−4.40
	S.e.	1.87	1.74	1.77	1.77	1.94	1.69	1.91	2.32
	Std	14.54	13.73	14.03	14.07	15.38	13.22	14.66	16.86
Panel C: Log-excess returns in local currency $rx^{£}_{t,t+k}$									
Bonds/T-bills	Mean	2.73	1.71	1.63	1.74	0.48	−2.25	−1.96	−1.14
	S.e.	0.60	0.55	0.51	0.47	0.50	0.66	0.67	0.87
Stocks/T-bills	Mean	6.32	5.79	4.37	4.30	2.83	−3.50	−4.21	−3.07
	S.e.	1.86	1.74	1.77	1.77	1.93	1.66	1.86	2.27
Stocks/Bonds	Mean	3.59	4.08	2.74	2.56	2.34	−1.25	−2.25	−1.93
	S.e.	1.86	1.78	1.80	1.80	1.93	1.73	1.86	2.40

Time-series averages of annualized log k-month returns on portfolios. The countries are sorted by year-over-year inflation minus 10-year inflation realized at month $t-1$ ($\pi_{t-12,t}-\pi_{t-120,t}$). The portfolios are re-sorted each month. The sample is 1950-2012. The data is monthly. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with only 10 countries in 1950, and ends with 31 countries in 2012. The standard errors, denoted "s.e.", were generated by bootstrapping 10,000 samples with replacement. "Std" denotes the time series standard deviation.

is not true in the time-series dimension: When a country's rate of inflation is higher than average for that country, this has a small, negative but statistically insignificant effect on real returns (see for a survey of the time-series evidence Bekaert and Wang 2010).[10]

[10] In their survey paper, Bekaert and Wang (2010), who build a large panel of countries to investigate the usefulness of stocks in hedging inflation risk, report negative slope coefficients on inflation innovations and expected inflation. When Bekaert and Wang (2010) control for industrial production growth in a multivariate regression

This cross-sectional relation between asset returns and inflation is confirmed when we limit the sample to developed countries. The unbalanced panel includes: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. These results are reported in Table A13, in the Online Appendix. Real stock returns decline from 8.04% in the first quintile to 3.59% in the last quintile, a decline of 4.45% (s.e. of 1.53%). For bonds, the corresponding spread is only 1.02%. This pattern results in a large decline in the equity premium of 3.77% from the first to the last portfolio. As we increase the holding period, these spreads decrease. The spread in real returns decreases from 4.32% at the 1-month horizon to 4.08% at the 3-month horizon, and 2.72% at the 12-month horizon. We also consider a balanced panel of countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom, and the United States) that report data at the start of the sample. When we sort these 11 countries into three portfolios, we still record a 2.09% spread in real stock returns between the highest and the lowest portfolio. The spread in realized inflation over this period is only 2.42%. On the contrary, the spread in real bond returns is only 1.20%. Higher local expected inflation implies lower real stock returns.

There is an important sample selection effect in this dataset. Countries that have experienced high and volatile inflation are less likely to issue local currency bonds. Further, if these countries do start issuing these bonds, they will do so after inflation has decreased. This is borne out by the numbers reported in Table A10 in Online Appendix D. The average rate of inflation in this extended panel is much higher (6.41% *per annum*), while the cross-sectional standard deviation of average inflation is 5.82%, almost 3 times higher than in the bond/stocks sample. When we add the countries who have not issued long-term bonds in local currency, the relation between stock returns and expected inflation increases becomes convex. Online Appendix D provides detailed results for the extended stocks-only sample. There is still a 6.61% spread in the real stock returns between the first and the last quintile. When sorting by lagged inflation in deviation from the mean, the results are even stronger: the spread in real stock returns in real stock returns between the first and the fifth quintile is 10.15% at the 1-month horizon. In this case, the last quintile contains countries with less volatile inflation (see Table A16 in the Online Appendix): the standard deviation is 3.12% in the last quintile versus 9.96% in the first quintile.

Finally, these results are robust to using alternative measures of expected inflation, either based on inflation surveys or nominal interest rates. We report these results in the Online Appendix.

of stock returns on inflation innovations and output growth, some of these inflation betas of stocks switch signs and become positive.

3.2 Pass-through dynamics in stock and bond markets

There is a large difference in the dynamics of the bond and stock returns in response to a change in expected inflation: Bond prices respond immediately to inflation news, but stocks respond slowly.

3.2.1 Sorting by lagged inflation. To illustrate these dynamics, Figure 3 plots the nominal (real) returns spreads (the fifth minus the first quintile) against the holding period on the x-axis in the top (bottom) panel. The countries are sorted by lagged inflation. The composition of the portfolios is fixed as we increase the holding period. In the left panels, we plot the the response of stock returns. At the 1-month holding period, nominal stock returns do not respond to the difference in expected inflation. At the 12-month holding period, the spread is still only 1.14 % *per annum*. On the contrary, the spread in nominal bond returns, shown in the right panels, does respond at the 1-month horizon; it starts at 3.81%.

The bottom panel plots real returns. As we increase the holding period, the spread in real stock returns decreases from 5.34% at the 1-month horizon to 3.64% at the 12-month horizon, while the spread in real bond returns decreases from 1.00% to 0.43%. These effects are transitory. After 5 years, the gap in real stock returns has closed completely. Recall that countries in the last quintile have experienced inflation that is more volatile. Clearly, the bond return spread is eliminated much faster compared to the stock return spread. This is suggestive of sluggish adjustment in the stock market.

The holding period matters. Boudoukh and Richardson (1993) examine the inflation hedging properties of U.S. stocks over longer holding periods, and they conclude that stocks provide an effective inflation hedge over longer holding periods (e.g., 5 years). Our paper confirms these findings in the cross section. All of the effects of inflation on real stock returns that we have documented disappear at horizons in excess of 5 years.

3.2.2 Sorting by lagged inflation in deviation from the mean. However, when we sort by lagged inflation in deviation from the 10-year average, the effect on real stock return differences initially increases and is much more persistent. Figure 4 plots the nominal (real) returns spreads (the fifth minus the first quintile) against the holding period on the x-axis in the top (bottom) panel. The composition of the portfolios is fixed as we increase the holding period. At the 60-month horizon, the spread in real stock returns is still 3.76%, while the spread in real bond returns is only 1.12%. Most of the catch-up after the first year seems to take place in countries with high inflation over the past 10 years, but not in countries that have transitioned to high inflation recently. These findings are consistent with the sticky nominal discount rate model in which stock investors overweight historical inflation but underweight recent inflation. As a result, the real stock stock response at one month is −69 basis points (5.13 divided by 7.35) per 100 basis points of inflation-deviation difference between

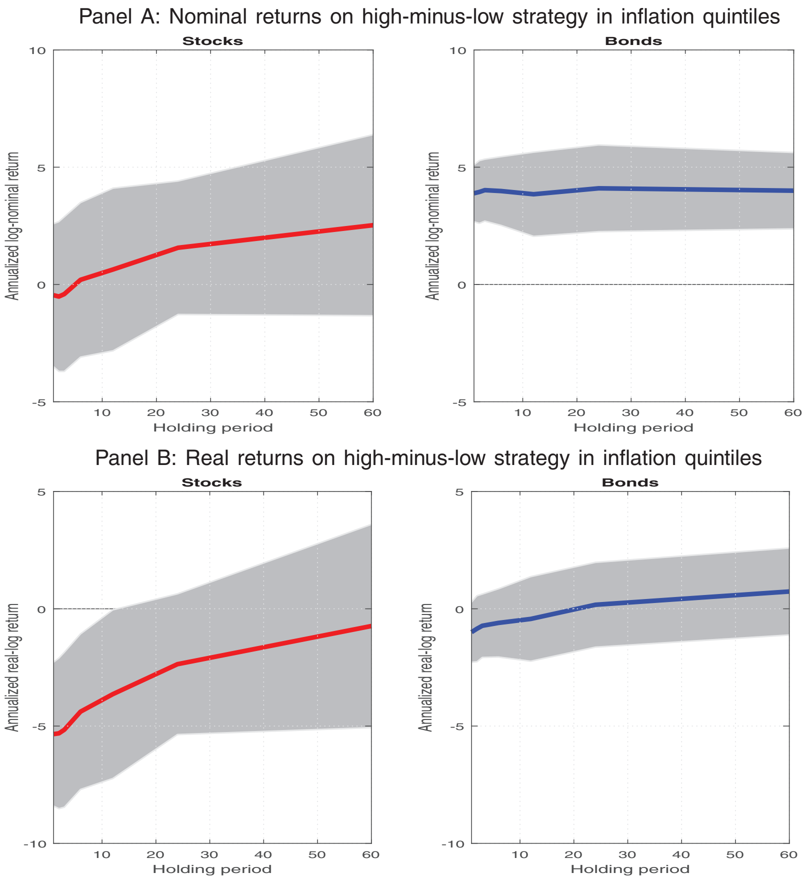

Figure 3
Dynamics of return spreads on portfolios sorted by lagged inflation
The top (bottom) panel plots the time-series average of log nominal (real) returns (annualized) on quintile five minus quintile one against the holding period. The left panel is for stocks. The right panel is for bonds. The countries are sorted by lagged year-over-year inflation ($\pi_{t-12,t}$). The grey areas depict two s.e. bands around the point estimates. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with ten countries in 1950, and ends with thirty-one countries in 2012.

the quintiles. At the 12-month (60 month) horizon, the response is 80 (59) basis points.

3.3 Stability of the cross-sectional relation between expected inflation and returns

The relation between inflation and returns varies over time. In the left panel, Figure 5 plots the cumulative log return on a long position in stocks and a short position in bills. The dashed line plots the first quintile (low inflation)

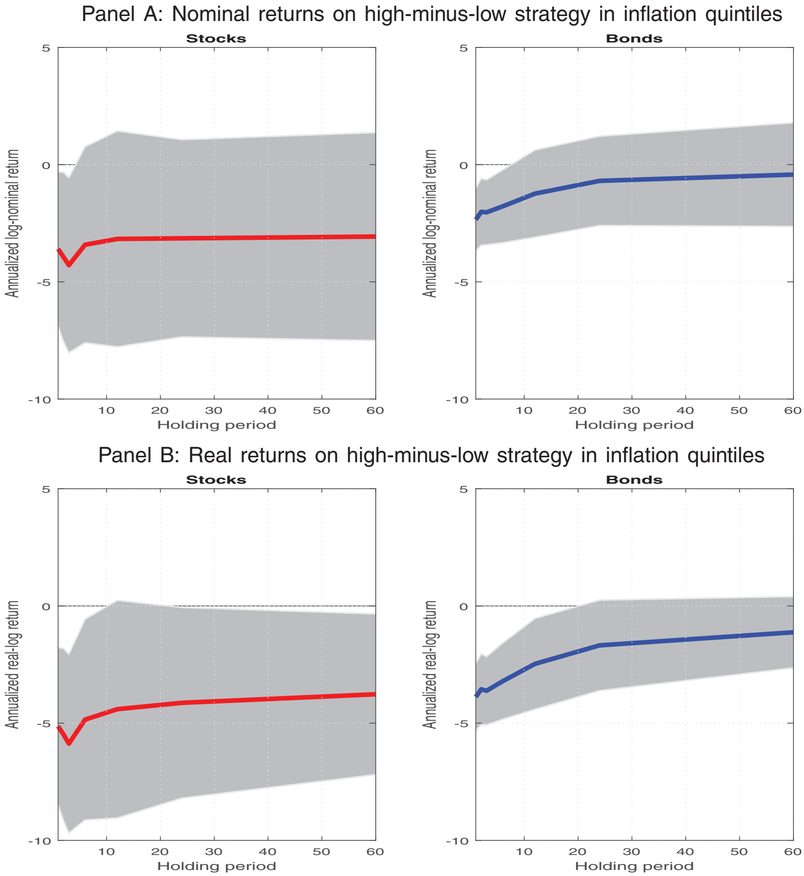

Figure 4

Dynamics of return spreads on portfolios sorted by lagged inflation in deviation from the average

The top (bottom) panel plots the time-series average of log nominal (real) returns (annualized) on quintile five minus quintile one against the holding period. The left panel is for stocks. The right panel is for bonds. The countries are sorted by lagged year-over-year inflation ($\pi_{t-12,t}$). The grey areas depict two s.e. bands around the point estimates. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with ten countries in 1950, and ends with thirty-one countries in 2012.

and the full one plots the last quintile (high inflation). The equity premium is consistently higher in low-inflation portfolios than in high-inflation portfolios. The right panel shows the equivalent cumulative returns for long positions in equity and short positions in bonds. In the highest inflation quintile, investors with this long-short position have lost money over the past 6 decades.

The spread in real stock returns between the extreme quintiles in the stock/bonds sample (the stock-only sample) varies from −11.00% (−12.80%) in the 1950s to −11.55% (−11.57%) in the 1960s, −2.77% (−9.86%) in the

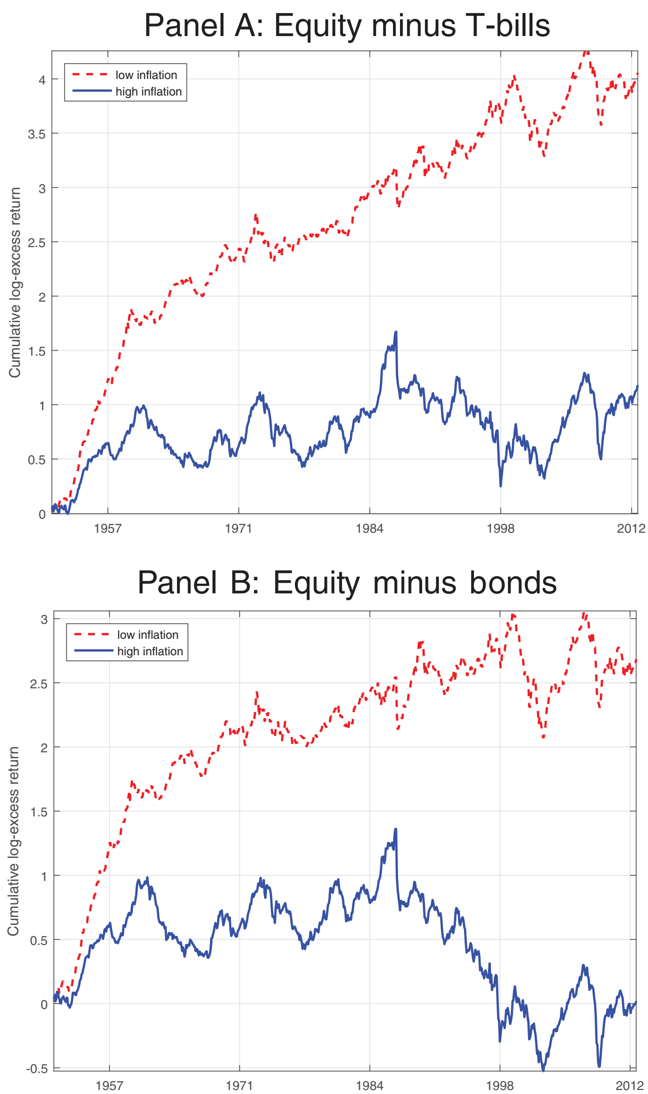

Figure 5
Cumulative stock returns on inflation-sorted portfolios
The figure plots cumulative log returns on a long position in stocks and a short position in bills in the left panel (bonds in right panel) for the first and the last quintile of the inflation-sorted countries. The countries are sorted by year-over-year inflation realized at month $t-1$ ($\pi_{t-12,t}$). The portfolios are re-sorted each month. The sample is 1950–2012. The data are monthly. The sample includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The sample starts with only 10 countries in 1950, and ends with 31 countries in 2012.

1970s, −3.36% (−2.33%) in the 1980s, −6.50% (−4.29%) in the 1990s, and 4.62% (−.41%) in the 2000s. Hence, the last decade is the only exception. Stocks of countries with low realized inflation consistently deliver higher average log excess returns over the entire sample, even though the differences narrow considerably in the 1970s and 1980s. By contrast, we only see real bond return differences in the first 3 decades.[11] The same numbers for the portfolios sorted by lagged inflation in deviations from the 10-year average are: −13.53% (−13.83%) in the 1950s, −12.05% (−12.13%) in the 1960s, −4.56% (−10.30%) in the 1970s, 2.27% (−12.13%) in the 1980s, 1.78% (−2.92%) in the 1990s, and −5.23% (−4.91%) in the 2000s.

This cross-sectional relation between expected inflation and real returns weakens in the late 1990s, exactly when stocks around the world switched from positive to negative bond betas. When global bond markets signal that higher expected inflation goes hand in hand with lower discount rates (see Online Appendix B), the cross-sectional spread in real stock returns between the highest- and lowest-inflation quintile shrinks. This is exactly when the risk-based explanation would imply that bets against inflation would be most profitable, because the negative covariance signals that high-expected-inflation states of the world are perceived to be good for the average investor (e.g., when output growth is dominated by demand shocks).

Around the same time, there was also a noticeable decrease in the persistence of inflation around the world. This decline in persistence may partly be due to changes in the monetary policy framework which have taken place in most developed countries starting in 1990s (see Wright 2011). In the last decade, the autocorrelation of inflation actually turned negative for the average country in our sample (see Online Appendix C).[12] When inflation is not persistent, sticky nominal discount rates have a much smaller effect on valuations (see Section 4.1). Hence, the time variation in the high/low inflation spread seems broadly consistent with the sticky discount rate hypothesis.

In the next section, we explicitly demonstrate that the time variation in the spreads is consistent with the sticky discount rate model: higher current inflation spreads and lower historical inflation predict larger future real return spreads in the data.

3.4 Time variation in pass-through

This section provides direct time-series evidence that stock market investors overweight historical long-run inflation in setting nominal discount rates in stock markets, consistent with the sticky nominal discount rate hypothesis in

11 Detailed results in Online Table 12.

12 It follows that lagged inflation may no longer be a good measure of expected inflation over this sample. In Online Appendix H, we use survey measures of 1-year expected inflation instead of lagged inflation, and we find that even in the last 15 years, real stocks returns are significantly lower in countries with higher-than-average expected inflation, but real bond returns are not.

Section 4.1. We find that real stock returns are lower in high-inflation countries, but this difference decreases as long-run inflation increases in the high inflation countries. This is not true of bond returns.

We use average inflation over the past 10 years as our measure of θ. To document the incomplete pass-through of inflation to nominal returns, we run forecasting regressions of future log return spreads between portfolio 5 and portfolio 1, for nominal returns, inflation, real returns and excess returns, all in logs–on predictor variables $\boldsymbol{X}_t$:

$$r^{5,\pounds}_{t,t+k} - r^{1,\pounds}_{t,t+k} = \beta^{\pounds}_0 + \boldsymbol{\beta}^{\pounds,\prime}\boldsymbol{X}_t, \tag{5}$$

$$\pi^{5}_{t,t+k} - \pi^{1}_{t,t+k} = \beta^{\pi}_0 + \boldsymbol{\beta}^{\pi,\prime}\boldsymbol{X}_t, \tag{6}$$

$$r^{5}_{t,t+k} - r^{1}_{t,t+k} = \beta_0 + \boldsymbol{\beta}^{\prime}\boldsymbol{X}_t, \tag{7}$$

$$rx^{5}_{t,t+k} - rx^{1}_{t,t+k} = \beta^{rx}_0 + \boldsymbol{\beta}^{rx,\prime}\boldsymbol{X}_t. \tag{8}$$

In Table 4, the vector of predictors $\boldsymbol{X}_t$ includes inflation over the past 10 years ($\pi^{5}_{t-10,t} - \pi^{1}_{t-10,t}$) and inflation over the past year ($\pi^{5}_{t-1,t} - \pi^{1}_{t-1,t}$). We refer to the first variable as long-run inflation, the second variable as lagged inflation. Note that the coefficients in Equation 7 equal the coefficients in Equation 5 minus the coefficients in Equation 6. The excess returns in Equation 8 are not clean measures of risk premiums because the short leg involves interest rate risk. To correct for the autocorrelation induced by overlapping windows and heteroskedasticity, we report Hansen and Hodrick (1980) with $12k$ lags and Newey and West (1987) t-statistics (with the Bartlett kernel).

The results for stocks are reported in Table 4. Panel A of Table 4 reports the results obtained using only long-run inflation as a predictor. The first five columns report results for Equation 5. A 100-basis-point increase in long-run inflation accrued over the past 10-years increases nominal stock returns by 79 basis points at the 1-year horizon to 110 basis points at the 5-year horizon. These slope coefficients are estimated precisely, even after adjustments for autocorrelation in the errors induced by the overlap in returns and heteroskedasticity. The pass-through of long-run inflation (over long horizons) to nominal stock returns is more than 100%, even at the 5-year horizon.

Next, we consider inflation. The next 5 columns report the same forecasting regression results for Equation 6, with log inflation on the left hand side of the regression. A 100-basis-point increase in inflation over the past 10 years increases log inflation by only 26 basis points at the 1-year horizon to 31 basis points *per annum* at the 5-year horizon. Hence, nominal stock returns seem to respond too strongly to the historical rate of inflation.

The next five columns report real returns (Equation 7). Since we work with log real returns, the estimated coefficients equal those in the second panel minus those in the first panel. A 100-basis-point increase in inflation over the past 10-years increases log inflation by 53 basis points at the 1-year horizon to 79 basis

Table 4
Stock return predictability: developed countries

Horizon k		*Nominal-log returns $r^{\$}_{t,t+k}$*					*Inflation $\pi_{t,t+k}$*					*Real-log returns $r_{t,t+k}$*					*Log-excess returns $rx_{t,t+k}$*				
		Equation 5					*Equation 6*					*Equation 7*					*Equation 8*				
in years		β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2
Panel A: X_t: *Long-run inflation*																					
1	Constant	−1.76	−2.95	−1.61	−1.59	0.05	2.55	19.25	7.86	5.27	0.11	−4.31	−7.08	−3.87	−3.29	0.02	−3.17	−5.29	−2.93	−2.50	0.01
	Long-run	0.79	6.47	3.13	2.95	0.05	0.26	9.63	3.63	2.50	0.11	0.53	4.27	2.27	2.02	0.02	0.27	2.18	1.10	0.90	0.00
2	Constant	−2.11	−4.65	−2.18	−1.62	0.18	2.20	17.63	6.20	3.62	0.11	−4.31	−9.13	−3.79	−2.52	0.12	−3.26	−7.12	−2.85	−1.94	0.06
	Long-run	1.21	12.82	5.77	4.06	0.18	0.25	9.68	2.87	1.67	0.11	0.95	9.76	3.89	2.73	0.11	0.66	6.99	2.57	1.68	0.06
3	Constant	−1.84	−4.85	−2.42	−1.56	0.23	1.89	16.29	5.61	3.13	0.15	−3.73	−9.58	−4.15	−2.51	0.14	−2.80	−7.49	−3.07	−1.97	0.08
	Long-run	1.17	14.82	7.13	5.08	0.23	0.28	11.35	3.17	1.63	0.15	0.90	11.02	4.82	4.43	0.14	0.63	8.03	3.19	2.61	0.08
4	Constant	−1.53	−4.28	−2.32	−1.45	0.22	1.64	14.79	5.17	2.81	0.19	−3.17	−8.89	−4.61	−2.64	0.13	−2.32	−6.81	−3.37	−1.98	0.06
	Long-run	1.06	14.01	6.79	3.75	0.22	0.30	12.75	3.47	1.63	0.19	0.76	10.10	5.65	4.87	0.12	0.51	7.02	3.66	3.15	0.06
5	Constant	−1.16	−3.42	−1.73	−1.40	0.24	1.46	13.37	4.36	2.58	0.20	−2.63	−7.75	−3.85	−2.97	0.14	−1.80	−5.51	−2.66	−1.91	0.07
	Long-run	1.10	14.93	7.36	4.08	0.24	0.31	13.06	3.26	1.53	0.20	0.79	10.77	6.42	5.26	0.14	0.53	7.43	4.24	3.07	0.07
Panel B: X_t: *Long-run and current inflation*																					
1	Constant	−1.83	−1.80	−0.95	−0.68	0.05	−0.33	−1.84	−0.80	−0.53	0.41	−1.50	−1.46	−0.75	−0.54	0.04	−1.60	−1.58	−0.82	−0.58	0.01
	Long-run	0.79	6.42	3.12	3.19	0.05	0.21	9.66	4.23	3.61	0.41	0.58	4.65	2.29	2.27	0.04	0.29	2.38	1.19	1.07	0.01
	lagged	0.01	0.08	0.03	0.02	0.50	19.57	5.98	3.93	−0.49	−3.40	−1.39	−1.01	−0.27	−1.92	−0.81	−0.59				
2	Constant	−0.51	−0.68	−0.38	−0.25	0.19	−0.52	−3.09	−1.23	−0.69	0.43	0.01	0.01	0.01	0.00	0.17	0.03	0.04	0.02	0.01	0.10
	Long-run	1.23	13.11	6.39	4.53	0.19	0.20	9.59	4.80	3.91	0.43	1.03	10.85	5.86	4.16	0.17	0.72	7.73	3.61	2.41	0.10
	lagged	−0.28	−2.63	−1.20	−0.72	0.47	20.17	5.62	2.93	−0.75	−7.02	−3.04	−1.92	−0.57	−5.44	−2.35	−1.54				
3	Constant	−1.49	−2.36	−1.23	−0.70	0.23	−0.49	−3.07	−1.16	−0.61	0.43	−1.00	−1.58	−0.83	−0.50	0.18	−0.73	−1.19	−0.62	−0.37	0.10
	Long-run	1.18	14.78	7.45	5.55	0.23	0.22	11.17	5.32	3.85	0.43	0.96	11.87	7.09	5.22	0.18	0.67	8.63	4.44	3.54	0.10
	lagged	−0.06	−0.70	−0.33	−0.18	0.41	18.83	5.18	2.46	−0.47	−5.38	−2.57	−1.72	−0.36	−4.22	−1.89	−1.30				
4	Constant	−2.34	−4.00	−1.78	−1.07	0.22	−0.43	−2.79	−1.08	−0.56	0.42	−1.91	−3.29	−1.61	−1.05	0.13	−1.46	−2.62	−1.25	−0.76	0.07
	Long-run	1.04	13.61	7.25	4.93	0.22	0.25	12.34	5.56	3.78	0.42	0.79	10.45	6.84	4.56	0.13	0.53	7.25	4.55	3.64	0.07
	lagged	0.14	1.75	0.74	0.46	0.36	17.00	5.01	2.28	−0.22	−2.72	−1.36	−1.21	−0.15	−1.95	−0.91	−0.66				
5	Constant	−2.09	−3.79	−1.71	−1.19	0.25	−0.41	−2.67	−1.01	−0.57	0.40	−1.68	−3.06	−1.53	−1.19	0.15	−1.16	−2.18	−1.06	−0.69	0.08
	Long-run	1.07	14.38	8.03	5.68	0.25	0.25	12.21	5.58	3.25	0.40	0.82	11.02	7.66	5.25	0.15	0.55	7.60	5.13	3.56	0.07
	lagged	0.16	2.13	1.03	0.65	0.33	15.44	4.55	2.21	−0.17	−2.18	−1.32	−1.35	−0.11	−1.53	−0.87	−0.62				

Regression of future stock returns on lagged and long-run inflation. Regressions specified in Equation 5, Equation 6, Equation 7, and Equation 8. Portfolios of countries sorted by lagged year-over-year inflation at month t. Portfolios are re-sorted each month. Standard errors are generated by bootstrapping the sample 10,000 times. Sample: 1950-2012. Monthly data. All returns are annualized. The subset of developed countries includes Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We report Hansen and Hodrick (1980) with $12k$ lags and Newey and West (1987) t-stats (with the Bartlett kernel).

points *per annum* at the 5-year horizon. These coefficients are significantly different from zero. At the 2-year horizon, the effect is 95 basis points. The last five report the results for forecasting excess returns in Equation 8.

Panel B in Table 4 reports the forecasting results that we obtained when controlling for lagged inflation. The results are essentially unchanged, because the slope coefficients in the regression of nominal returns on current inflation (i.e., inflation in the year preceding t) are very small, or even negative. In Equation 5, the pass-through of past inflation (over long horizons) to nominal stock returns is more than 100%, even when controlling for current inflation. On the contrary, in forecasting actual inflation in Equation 6, current inflation is assigned a large weight that always exceeds the weight on past inflation (at all horizons). As we would expect in the case of AR processes, the weight assigned to lagged inflation decreases as we increase the forecasting horizon from 0.50 to 0.33.

At the 1-year horizon, the coefficient on long-run inflation (lagged inflation) in the real returns regression (Equation 7) is 0.58 (−0.49). The coefficients on long-run inflation are close to 90 basis points at $k=2$ and $k=3$. The negative loadings on current inflation in a regression of real returns simply reflect the small or non-existent pass-though of current inflation to nominal returns. As before, these slope coefficients are simply the difference between the coefficients in the nominal and the inflation forecasting panel. As a result, a 100-basis-point increase in the historical inflation difference translates into a 55-basis points increase in the expected log excess return on stocks in the fifth relative to the first quintile.[13]

There is no evidence of sticky discount rates in bond markets. Table 5 reports the evidence for bond returns. We run the same regressions with the returns on bond portfolios on the left hand side. In Equation 5, the coefficients on long-run inflation are only about half the size of those estimated for nominal stock returns: they vary between 58 and 49 basis points, depending on the horizon. As a result, real bond returns are much less sensitive to the long-run component of inflation, while excess returns on bonds at all horizons are completely unresponsive to the long-run component of inflation. Using the Hansen and Hodrick (1980) standard errors, we cannot reject the null that long-run inflation has no effect on real bond returns or excess returns on bonds.

Finally, Table 6 shows the same results when controlling for the current yield spread, a forward-looking measure of expected inflation. Panel A reports the results for stock returns. Long-run inflation still has a large, significant effect on real stocks returns. The coefficients on Panel B reports results for bond returns. Now, we cannot reject the null that long-run inflation has no effect on bond excess returns at any horizon. In this case, the long-run component of inflation no longer has any significant bearing on nominal bond returns, but it still has a

13 We report similar evidence for the larger sample of countries in Online Table A26.

Table 5
Bond return predictability: developed countries

Horizon k		*Nominal-log returns* $r^{\$}_{t,t+k}$					*Inflation* $\pi_{t,t+k}$					*Real-log returns* $r_{t,t+k}$					*Log-excess returns* $rx_{t,t+k}$				
		Equation 5					*Equation 6*					*Equation 7*					*Equation 8*				
in years		β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2
1	Constant	1.53	3.39	1.86	1.53	0.10	−0.33	−1.84	−0.80	−0.53	0.41	1.86	3.91	2.20	1.88	0.10	1.76	4.31	2.38	2.25	0.04
	Long-run	0.49	8.92	3.47	2.44	0.09	0.21	9.66	4.23	3.61	0.41	0.27	4.74	1.86	1.36	0.10	−0.01	−0.24	−0.13	−0.10	0.04
	lagged	−0.04	−0.68	−0.33	−0.25		0.50	19.57	5.98	3.93		−0.54	−8.13	−3.50	−2.60		−0.33	−5.70	−3.00	−2.42	
2	Constant	1.72	5.12	2.64	1.85	0.21	−0.52	−3.09	−1.23	−0.69	0.43	2.24	6.33	3.62	2.67	0.21	2.26	7.94	4.52	3.37	0.12
	Long-run	0.58	13.99	4.64	2.41	0.21	0.20	9.59	4.80	3.91	0.43	0.38	8.72	3.31	1.80	0.20	0.07	2.07	1.09	0.65	0.12
	lagged	−0.10	−2.19	−0.99	−0.85		0.47	20.17	5.62	2.93		−0.57	−11.65	−4.84	−3.10		−0.40	−9.96	−5.09	−3.32	
3	Constant	0.78	2.72	1.27	0.83	0.25	−0.49	−3.07	−1.16	−0.61	0.43	1.27	4.13	2.20	1.28	0.14	1.54	6.62	3.46	1.87	0.06
	Long-run	0.55	14.94	4.25	1.99	0.25	0.22	11.17	5.32	3.85	0.43	0.32	8.24	2.61	1.34	0.13	0.04	1.26	0.53	0.29	0.06
	lagged	0.08	1.99	0.79	1.21		0.41	18.83	5.18	2.46		−0.33	−7.82	−2.94	−1.67		−0.22	−6.78	−2.96	−1.61	
4	Constant	0.11	0.40	0.17	0.10	0.28	−0.43	−2.79	−1.08	−0.56	0.42	0.53	1.89	0.90	0.47	0.08	0.99	4.60	2.05	0.93	0.02
	Long-run	0.51	14.68	3.89	1.86	0.28	0.25	12.34	5.56	3.78	0.42	0.26	7.14	2.16	1.14	0.08	0.00	0.00	0.00	0.00	0.01
	lagged	0.19	5.26	1.86	2.03		0.36	17.00	5.01	2.28		−0.17	−4.23	−1.49	−0.79		−0.10	−3.31	−1.33	−0.62	
5	Constant	−0.01	−0.04	−0.02	−0.01	0.33	−0.41	−2.67	−1.01	−0.57	0.40	0.40	1.55	0.73	0.39	0.10	0.92	4.63	2.03	0.92	0.02
	Long-run	0.55	16.44	4.09	2.05	0.33	0.25	12.21	5.58	3.25	0.40	0.29	8.42	2.59	1.38	0.10	0.02	0.87	0.33	0.19	0.01
	lagged	0.18	5.29	1.79	2.07		0.33	15.44	4.55	2.21		−0.15	−4.11	−1.40	−0.74		−0.09	−3.43	−1.30	−0.61	

Regression of future bond returns on lagged and long-run inflation. Regressions specified in Equation 5, Equation 6, Equation 7, and Equation 8. Portfolios of countries sorted by lagged year-over-year inflation at month t. Portfolios are re-sorted each month. Standard errors are generated by bootstrapping the sample 10,000 times. Sample: 1950-2012. Monthly data. All returns are annualized. The subset of developed countries includes Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We report Hansen and Hodrick (1980) with $12k$ lags and Newey and West (1987) t-stats (with the Bartlett kernel).

Table 6
Stock and bond return predictability

Horizon k		Nominal-log returns $r^{£}_{t,t+k}$					Real-log returns $r_{t,t+k}$					Log-excess returns $rx_{t,t+k}$				
		Equation 5					Equation 7					Equation 8				
in years		β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2	β	*ols*	*nw*	*hh*	R^2
Panel A: Stock returns																
1	Constant	−2.05	−3.03	−1.60	−1.29	0.05	−3.58	−5.23	−2.72	−2.14	0.02	−2.24	−3.30	−1.75	−1.40	0.01
	Yield	0.44	1.94	0.92	0.65	0.05	−0.28	−1.22	−0.59	−0.42	0.02	−0.50	−2.22	−1.06	−0.74	0.01
	Long-run	0.58	3.63	2.05	1.86		0.57	3.53	2.16	2.02		0.46	2.87	1.68	1.51	
2	Constant	−2.43	−5.01	−2.21	−1.57	0.16	−3.77	−7.53	−3.24	−2.19	0.09	−2.45	−5.03	−2.22	−1.61	0.06
	Yield	0.44	2.72	1.21	0.80	0.16	−0.24	−1.40	−0.62	−0.43	0.09	−0.49	−2.97	−1.29	−0.88	0.06
	Long-run	0.92	7.82	3.17	2.21		0.92	7.62	2.93	2.15		0.80	6.81	2.78	1.91	
3	Constant	−2.59	−6.66	−2.81	−1.73	0.23	−3.74	−9.33	−3.74	−2.20	0.11	−2.52	−6.44	−2.69	−1.74	0.06
	Yield	0.71	5.47	2.23	1.54	0.23	0.14	1.01	0.41	0.30	0.10	−0.15	−1.17	−0.47	−0.35	0.06
	Long-run	0.73	7.63	3.05	3.02		0.67	6.78	2.42	2.37		0.60	6.18	2.42	2.25	
4	Constant	−2.37	−6.84	−2.97	−1.67	0.24	−3.37	−9.57	−3.92	−2.18	0.10	−2.22	−6.42	−2.73	−1.57	0.04
	Yield	0.91	7.92	3.28	2.16	0.24	0.41	3.53	1.46	1.11	0.09	0.12	1.03	0.42	0.31	0.04
	Long-run	0.48	5.51	2.61	4.12		0.37	4.20	1.72	2.23		0.32	3.64	1.62	2.17	
5	Constant	−1.91	−6.07	−2.54	−1.91	0.28	−2.81	−8.78	−3.42	−2.47	0.12	−1.75	−5.58	−2.27	−1.63	0.05
	Yield	0.85	8.22	3.51	1.97	0.28	0.41	3.82	1.62	0.96	0.11	0.14	1.39	0.58	0.35	0.05
	Long-run	0.52	6.24	3.05	4.28		0.39	4.62	1.82	1.71		0.32	3.88	1.72	1.92	
Panel B: Bond returns																
1	Constant	−0.39	−1.55	−0.98	−0.87	0.29	−1.93	−6.48	−3.78	−3.04	0.04	−0.58	−2.25	−1.34	−1.13	0.01
	Yield	1.19	14.25	6.29	5.16	0.29	0.48	4.89	2.26	1.77	0.04	0.26	3.00	1.46	1.25	0.01
	Long-run	0.00	−0.02	−0.01	−0.01		−0.01	−0.12	−0.09	−0.07		−0.12	−1.95	−1.63	−1.42	
2	Constant	−0.26	−1.62	−0.76	−0.50	0.52	−1.60	−7.21	−3.48	−2.00	0.10	−0.28	−1.55	−0.76	−0.51	0.03
	Yield	1.21	22.55	11.68	8.14	0.52	0.53	7.12	3.55	2.39	0.10	0.28	4.69	2.44	1.75	0.03
	Long-run	0.01	0.31	0.14	0.11		0.02	0.32	0.14	0.13		−0.10	−2.39	−1.16	−0.91	
3	Constant	0.01	0.11	0.05	0.03	0.68	−1.14	−6.53	−3.06	−1.70	0.16	0.08	0.63	0.31	0.20	0.07
	Yield	1.19	32.43	16.50	14.92	0.68	0.61	10.50	5.15	3.20	0.15	0.32	7.21	3.72	2.93	0.07
	Long-run	−0.04	−1.51	−0.79	−0.84		−0.10	−2.37	−1.01	−0.86		−0.18	−5.34	−2.71	−2.15	
4	Constant	0.02	0.24	0.12	0.06	0.74	−0.98	−6.55	−3.54	−1.76	0.23	0.17	1.39	0.73	0.37	0.12
	Yield	1.17	37.52	21.09	24.32	0.74	0.67	13.61	6.66	3.62	0.22	0.38	9.66	5.29	3.56	0.12
	Long-run	−0.06	−2.53	−2.89	−2.60		−0.17	−4.46	−2.57	−1.25		−0.22	−7.45	−5.37	−2.72	
5	Constant	−0.06	−0.73	−0.40	0.79	−0.97	−7.24	−3.97	−1.94	0.27	0.09	0.87	0.47	0.23	0.15	
	Yield	1.10	40.91	25.78	0.79	0.65	14.67	6.93	3.81	0.27	0.39	11.06	6.15	3.99	0.15	
	Long-run	−0.02	−0.82	−0.92		−0.14	−4.08	−1.92	−0.84		−0.21	−7.59	−4.47	−2.16		

Regression of future stock and bond returns on yields and long-run inflation. Regressions specified in Equation 5, Equation 7, and Equation 8. Portfolios of countries sorted by lagged year-over-year inflation at month t. Portfolios are re-sorted each month. Standard errors are generated by bootstrapping the sample 10,000 times. Sample: 1950–2012. Monthly data. All returns are annualized. The subset of developed countries includes Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We report Hansen and Hodrick (1980) with $12k$ lags and Newey and West (1987) t-stats (with the Bartlett kernel).

large and statistically significant effect on nominal and real stocks returns, as well as excess returns.

Our empirical results are consistent with the notion that local stock market investors' long-run discount rates respond more slowly to local news about expected inflation compared with bond market investors' discount rates. As a result, subsequent realized returns are higher than they expect. Interestingly, baskets of foreign stocks provide better inflation hedges, because of the faster response of the exchange rate to inflation (see Online Appendix G which explores the returns on baskets of foreign stocks).

4. What Drives the Incomplete Pass-Through? Alternative Explanations

We have established that nominal stock returns seem sluggish in responding to changes in local inflation. There are two distinct ways to interpret these results. First, investors do not have rational inflation expectations. Second, investors have rational inflation expectations and fully understand this relation between inflation and returns. This section reviews all potential explanations.

4.1 Sticky information models and under-reaction of nominal discount rates

We consider a model in which stock investors do not have rational inflation expectations. We use a simple version of the Mankiw and Reis (2002) model of sticky information to analyze the effect on stock prices. In any given period, only a fraction $(1-\lambda)$ of inattentive agents update their information set each period. When they update, they use rational expectations. Consistent with this hypothesis, Coibion and Gorodnichenko (2015) document evidence of information stickiness in inflation-expectation surveys that is economically significant. Rational inattention could potentially rationalize stickiness.

To simplify the analysis, we assume that individual investors/analysts specialize in a single stock and compute discount rate and cash flow estimates to value this stock. On the cash flow side, investors forecast nominal stock-specific cash flow growth, but on the discount-rate side investors have to confront the inflation forecasting problem directly when setting nominal discount rates.[14]

Clearly, when valuing a stock, investors face a 2-dimensional forecasting problem. When forecasting cash flows at the firm level, investors directly forecast the firm's cash flows in dollars rather than real terms. On the cash flow side, they do not have to confront the macro-inflation-forecasting challenge directly. Instead, they forecast firm i's dollar revenue growth.[15] Given the

[14] Investors cannot simply use nominal yields plus an equity risk adjustment to price the nominal cash flows, because these nominal yields include an inflation risk premium that does not apply if the stock's dividends are indexed to inflation; investors need expected inflation under $\mathbb{P}$, not $\mathbb{Q}$.

[15] Aggregated across all firms i, these nominal cash flow projections naturally imply an expected future path for aggregate inflation when combined with real cash flow projections. However, most investors do not attack this

high variance of firm-specific shocks relative to that of aggregate shocks, it is natural to assume that information is stickier for the macro inflation forecasting problem investors face when setting discount rates than for the micro-revenue-forecasting problem: $\lambda_r > \lambda_c$.[16]

There is a continuum of stocks/experts. When we aggregate across all stock market investors, we then end up with discount rates that are sticky. Obviously, this creates profit opportunities for sophisticated investors who are not subject to sticky inflation expectations, but instead use superior and continuously updated inflation forecasts. However, shorting the stock market in a country that has recently experienced high inflation is likely to be a low Sharpe-ratio proposition, because stock returns are subject to lots of quantitatively dominant sources of risk other than inflation risk. These investors may choose to deploy scarce capital elsewhere.

Equation 1 has to hold for every sample path. That means it also holds for every individual investor's expectation for his individual stock:

$$pd_t^i = \frac{k^i}{1-\rho} + \mathbb{E}_{t-l^c(i)}^i \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d_{t+j}^{i,\$} \right] - \mathbb{E}_{t-l^r(i)}^i \left[\sum_{j=1}^{\infty} \rho^{j-1} r_{t+j}^{i,\$} \right], \qquad (9)$$

where $t-l^c(i)$ $(t-l^r(i))$ denotes the last period when i updated her cash flow (discount rate) forecasts. The nominal cash flow forecast involves the growth of firm i's earnings, which do not depend directly on economy-wide inflation but on the growth rate of quantities and prices for that firm: $\Delta d_{t+1}^{i,\$} = \Delta q_{t+1}^i + \pi_{t+1}^i$, where π_{t+1}^i denotes the growth rate of firm i's price. The cross-sectional average of π_{t+1}^i is the economy-wide rate of inflation.

When they update their information set, investors use the actual data-generating process (DGP) for inflation, specified as: $\pi_t = (1-\phi)\theta + \phi\pi_{t-1} + u_t$, where $0 < \phi < 1$ denotes the AR(1) coefficient, while θ is the investor's estimate of the unconditional mean of inflation. To keep the analysis simple, we assume that the real aggregate quantity growth and real stock returns expected by the investors is constant over time: $\mathbb{E}_t^*[r_{t+1}^i] = \mu_r$ and $\mathbb{E}_t^*[\Delta q_{t+1}^i] = \mu_q$.

Next, we use the average log price-dividend ratio as an approximation for the market's log price-dividend ratio. The log of the average price-dividend ratio equals the average log price-dividend ratio plus higher-order cross-sectional moments: $pd_t^m = pd_t + \sum_{j=2}^{\infty} \kappa_{j,t}[pd_{i,t}]$, where $\kappa_{j,t}$ denotes the $j-th$

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macro-forecasting-problem for each firm. Instead, they focus on the micro version, involving only a few firms, because of limited capacity to process information.

[16] Duffee (2014) computes that news about expected inflation over the life of the bond only account for 10% to 20% of the shocks to Treasury yields, leaving stocks to real rates and term premiums to account for the rest. Surely, for stocks, this fraction is an order of magnitude smaller, because stocks are claims to real cash flows. In addition, recomputing the appropriate nominal discount rates when expected inflation changes to reprice the nominal cash flows of stocks is not an easy task. Simply computing the actual duration of stocks is hard. Repricing nominal bonds when expected inflation changes is simple by comparison. As a result, a fraction of stock market investors may rationally decide not to continuously reprice stocks, given a limited capacity to process information, simply because inflation innovations account for a small fraction of total stock return variation, but they account for a much larger fraction of bond return variation.

cross-sectional cumulant. We assume that the time variation in the market price/dividend ratio induced by the cross-sectional variance and higher-order moments is small.[17] By aggregating across individual stocks, we end up with the following expression for the average log of the price-dividend ratio:

$$pd_t = \frac{k}{1-\rho} + \mathbb{F}_t^c\left[\sum_{j=1}^{\infty}\rho^{j-1}\Delta d_{t+j}^{\$}\right] - \mathbb{F}_t^r\left[\sum_{j=1}^{\infty}\rho^{j-1} r_{t+j}^{\$}\right], \tag{10}$$

where $\mathbb{F}_t^i, i = \in\{c,r\}$, denotes the cross-sectional average of the sticky information forecasts. Reis (2006) shows that the cross-sectional average forecast of a variable x_t h periods from now is simply given by: $\mathbb{F}_t^i x_{t+h} = (1-\lambda)\sum_{j=0}^{\infty}\lambda_i^j \mathbb{E}_{t-j}x_{t+h}$. We can substitute the AR(1)-forecast of inflation into this expression to obtain the cross-sectional average inflation forecast: $\mathbb{F}_t\pi_{t+h} = (1-\lambda)\sum_{j=0}^{\infty}\lambda^j\phi^{j+h}(\pi_{t-j}-\theta)+\theta$. The h-period inflation forecast is an infinite moving average of past inflation. Plugging these expressions into the Campbell-Shiller expression in Equation 2 yields the following result for the aggregate log price-dividend ratio.

Proposition 1. The average log dividend price ratio is given by:

$$dp_t = constant + \sum_{j=0}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(\pi_{t-j}-\theta).$$

Given differential stickiness of the micro-cash-flow and macro-inflation forecasts, the log-dividend yield is an infinite moving average of past inflation. The moving average weights are governed by the relative degree of information stickiness in discount rates and cash flows. This expression applies quite generally, regardless of the specifics of the investor's SDF.

Proposition 2. Suppose investor i has a log real SDF m_{t+1}^i that is jointly normally distributed with $(\Delta d_{t+1}^{i,\$}, \pi_{t+1})$. Variances and covariances are constant. The individual stock's log price/dividend ratio is $pd_t^i = A_0^i + A_1^i\phi^{l^r(i)}(\pi_{t-l^r(i)} - \theta) + A_2^i\phi^{l^c(i)}(\pi_{t-l^c(i)}^i - \theta)$ with $A_1^i = -\frac{\phi}{1-\rho\phi}, A_2^i = \frac{\phi}{1-\rho\phi}$. Then the aggregate log price/dividend ratio is given by the expression in Proposition 1.

We show this by enforcing this expert's Euler equation:

$$\mathbb{E}^*\left[\exp(m_{t+1}^i - \pi_{t+1} + \Delta d_{t+1}^{i,\$} + \rho pd_{t+1}^i + k - pd_t^i)|\mathcal{F}_{t-l^r(i)}^r, \mathcal{F}_{t-l^c(i)}^c\right] = 1,$$

where the expert takes the probability of updating next period into account. To develop some intuition, we consider a benchmark case in which agents

[17] Provided that stock dividend payments do not covary with the price-dividend ratio, the time variation in the market log price-dividend ratio equals the time variation of the average log price-dividend ratio.

have rational expectations for the micro-cash-flow forecasting problem, but information is sticky for the macro-inflation-forecasting problem.

Corollary 1. When cash flow forecasts are not sticky ($\lambda_c = 0$), the average log dividend yield is given by

$$dp_t = constant + \frac{-\phi\lambda_r}{1-\rho\phi}(\pi_t - \theta) + \sum_{j=1}^{\infty} \frac{(\lambda_r)^j(1-\lambda_r)}{1-\rho\phi}\phi^{j+1}(\pi_{t-j} - \theta).$$

As expected, an increase in current inflation above the unconditional mean immediately lowers the dividend yield, or equivalently, lowers the returns expected by a rational investor. A fraction λ_r of agents fail to update inflation expectations. As a result, the nominal discount rate is too low. However, as more agents update in subsequent periods, discount rates start to increase and the dividend yield rises again, which explains the negative effect of lagged inflation on the dividend yield.

Next, we derive an expression for real stock returns on the market. We use L to denote the lag operator.

Corollary 2. The log real return can be expressed as:

$$r_{t+1} = constant + \Delta d_{t+1} + \sum_{j=0}^{\infty} \frac{(\lambda_r)^j(1-\lambda_r) - (\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}$$
$$(1-\rho L^{-1})(\pi_{t-j} - \theta).$$

The immediate effect of inflation on realized returns is given by: $\frac{\partial r_{t+1}}{\partial \pi_{t+1}} = -\rho\frac{(\lambda_c-\lambda_r)}{1-\rho\phi}\phi$, which is positive in case of relative information stickiness in discount rates ($\lambda_r > \lambda_c$). The discount rate adjust more slowly to inflation news than the cash flows do. In later periods, the discount rate is slowly adjusted upward, and the effect on real returns is negative. Further, we can trace out the impulse response of the return with respect to past inflation:

$$\frac{\partial r_{t+1}}{\partial \pi_{t-j}} = \frac{(\lambda_r)^j(1-\lambda_r\rho\phi)(1-\lambda_r) - (\lambda_c)^j(1-\lambda_c\rho\phi)(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}, j \geq 0.$$

To develop a better understanding for the model, we consider a calibrated version of the model at annual frequencies. We use $\rho = 0.95$. The AR(1) coefficient of inflation, $\phi = 0.90$, and we explore different values of $\lambda_r \in \{0.10, 0.20, 0.30\}$. To simplify the analysis, we abstract from stickiness on the cash-flow-projection side: $\lambda_c = 0$. Panel A in Figure 6 traces out the impulse response of log returns ($\frac{\partial r_{t+k}}{\partial \pi_t}$), the log dividend yield ($\frac{\partial dp_{t+k}}{\partial \pi_t}$), cumulative real

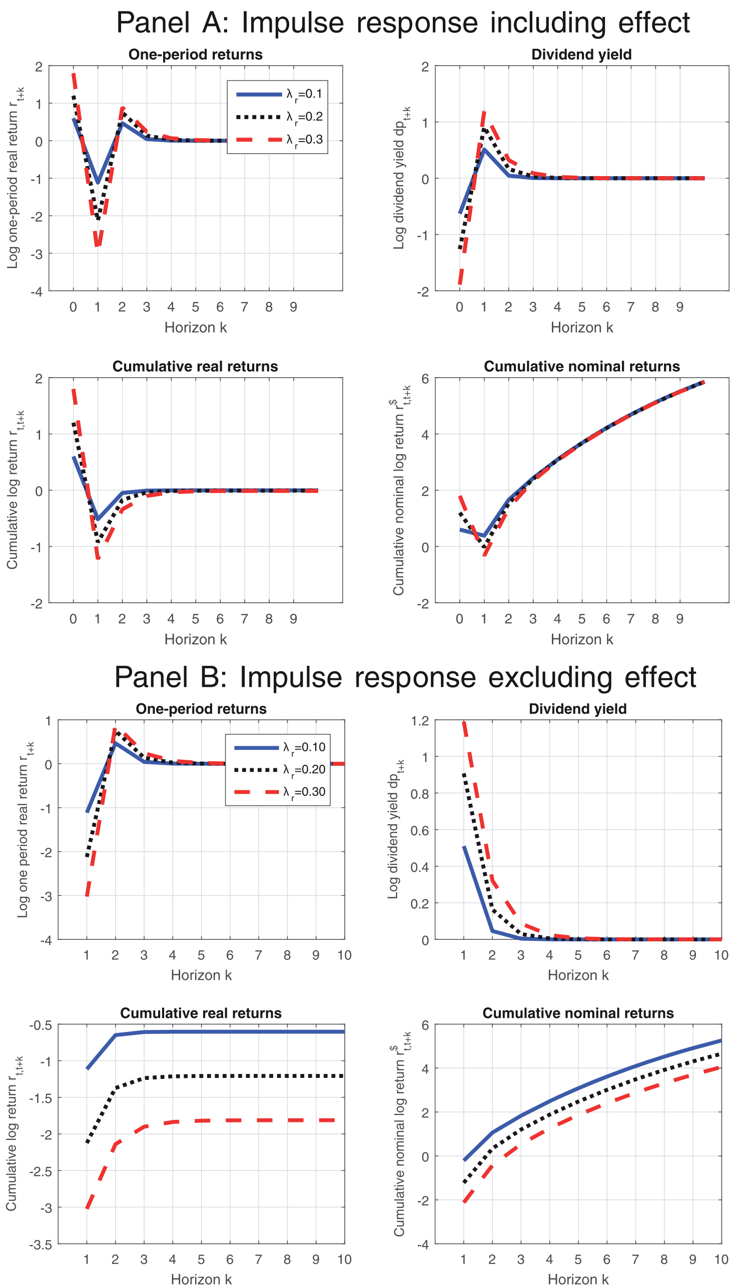

Figure 6
Impulse response to inflation

Plot of the impulse response (in pps) of log real returns ($\frac{\partial r_{t+k}}{\partial \pi_t}$), the log dividend yield, cumulative real returns ($\frac{\partial r_{t,t+k}}{\partial \pi_t}$) and cumulative nominal returns with respect to inflation shock of 1 pp at $k=0$. Panel A includes the effect at $t=0$. Panel B excludes $t=0$. We use $\rho=0.95$ and $\phi=0.90$ for $\lambda_r \in \{0.10, 0.20, 0.30\}$. Finally, we use $\lambda_c=0$.

log returns ($\frac{\partial r_{t+k}}{\partial \pi_t}$), and cumulative nominal log returns ($\frac{\partial r^{\$}_{t+k}}{\partial \pi_t}$) with respect to a one percentage-point surprise increase in the rate of inflation at $k=0$. Upon effect, an increase in inflation produces high positive realized real returns (top left panel) and a lower dividend yield (top right panel). Because a fraction of investors failed to update their inflation expectations, the nominal discount rate is set too low, thus pushing up the stock price. This effect is larger when inflation expectations are stickier. At $k=1$, one period later, an additional fraction $(1-\lambda_r)$ revises their inflation expectations upward to the rational level, pushing up the discount rate, delivering even larger real negative returns. The cumulative real return at $k=1$ is always negative. After that prices gradually recover. After 10 years, the dynamics of returns have largely died out. The last plot shows cumulative nominal log returns. Panel B in Figure 6 plots the same impulse responses starting at $k=1$. These responses correspond to the IRFs that we measure in the data. When only 10% of investors fail to adjust, the cumulative effect on long-horizon returns matches the effect we measure in the data (see Section 3): −0.59% in response to a 1% inflation shock (in deviation from the mean).

These dynamics imply that the returns expected by a fully rational agent are lower than normal after an inflation shock. That is apparent from the returns' impulse response starting at $k=1$. The stickiness of discount rates imputes predictability to real returns. The slope coefficient in a projection of real returns r_{t+1} on inflation π_t, controlling for all other inflation lags, can be recovered from:

$$\frac{\partial r_{t+1}}{\partial \pi_t} = b_r = \frac{(1-\lambda_r\rho\phi)(1-\lambda_r)-(1-\lambda_c\rho\phi)(1-\lambda_c)}{1-\rho\phi}\phi. \tag{11}$$

In our benchmark case, the slope coefficient is given by $b_r = -\frac{1-(1-\lambda_r\rho\phi)(1-\lambda_r)}{1-\rho\phi}\phi$, which is unambiguously negative if $0<\phi<1$. Higher inflation predicts lower real returns next period. After that, expected returns recover to normal as investors update: $\frac{\partial r_{t+1+j}}{\partial \pi_t} = \frac{(\lambda_r)^j(1-\lambda_r\rho\phi)(1-\lambda_r)}{1-\rho\phi}\phi^{j+1}, j\geq 1$, which is positive. Figure 7 provides an overview of the slope coefficient in the return predictability regression in the calibrated model with only discount rate stickiness. The graph plots the slope coefficient against the degree of stickiness, for various AR(1) coefficients. The slope coefficients are always negative. However, if inflation is highly persistent, then we observe strong predictability even if fewer than 10% of investors fail to adjust. Nevertheless, as persistence declines, much more stickiness needed in order to generate significant return predictability.

4.1.1 Evidence of stickiness and rational inattention. As shown, this model can replicate the slow response of nominal returns to inflation. The time variation in incomplete pass-through seems broadly consistent with sticky discount rates. Coibion and Gorodnichenko (2015) show that the stickiness in macro forecasts started to decline in the United States toward the end of the 1970s, as a result of the increased volatility of inflation and other macro

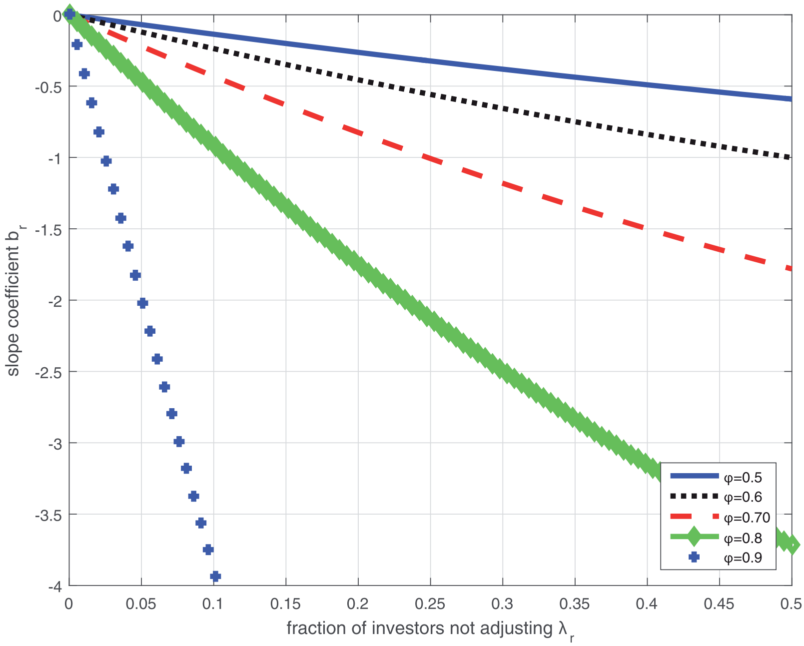

Figure 7
Return predictability
Plot of the slope coefficient in a projection of log real returns on lagged inflation ($\frac{\partial r_{t+1}}{\partial \pi_t}$), controlling for all lags of inflation against λ_r, the fraction of investors not adjusting discount rates. We use $\rho = 0.95$ and $\phi \in \{0.50, 0.60, 0.70, 0.80, 0.90\}$. Finally, we use $\lambda_c = 0$.

variables. We record the smallest real stock returns spreads between the inflation quintiles in the 1980s (see Subsection 3.3). After the 1980s, stickiness in macro forecasts picks up again according to Coibion and Gorodnichenko (2015), and the real stock return spread increased as well, although the real stock spreads in the 1950s and the 1960s were much higher than those observed towards the end of the sample. This could be due to the remarkable decrease in inflation persistence towards the end of the sample.

We have additional evidence that investors reallocate attention to inflation in environments with high and volatile inflation, thus reducing information stickiness. When we add the countries who have not issued long-term bonds in local currency, the relation between stock returns and expected inflation increases becomes convex. When we sort countries by lagged inflation, the last quintile includes countries with high and volatile inflation (see Table A15 in the Online Appendix). Average, realized inflation in the last quintile is 11.08% *per annum*, while the volatility of inflation in the last quintile is 2.40%, which is more than double the volatility of inflation in the first quintile. There is still a 6.61% spread in the real stock returns between the first and the last quintile, but there is a large increase in nominal stock returns from the fourth

Table 7
Lagged-vol-sorted portfolios for stocks-only panel

Horizon				1-month				3-month	12-month
Portfolio		Low	2	3	4	High	High-Low	High-Low	High-Low
Panel A: Log inflation $\pi_{t,t+k}$									
Sorted (vol)	Mean	1.14	1.48	1.92	2.69	7.80	6.66	6.54	6.21
	S.e.	0.03	0.03	0.04	0.05	0.26	0.26	0.46	0.92
Realized	Mean	3.51	3.94	4.60	5.62	9.79	6.28	6.07	5.88
	S.e.	0.14	0.16	0.18	0.21	0.32	0.33	0.49	0.87
Panel B: Nominal-log returns in local currency $r^{£}_{t,t+k}$									
T-bills	Mean	5.04	5.28	5.98	6.93	11.77	6.73	6.51	6.26
	S.e.	0.10	0.10	0.11	0.13	0.32	0.31	0.51	0.97
Stocks	Mean	10.48	9.69	10.45	11.37	16.00	5.52	5.70	6.43
	S.e.	1.71	1.77	1.89	1.91	2.11	1.79	1.97	2.66
Panel B: Real-log returns in local units of consumption $r^{*}_{t,t+k}$									
T-Bills	Mean	1.52	1.33	1.38	1.31	1.98	0.45	0.44	0.38
	S.e.	0.14	0.15	0.18	0.20	0.24	0.24	0.29	0.34
Stocks	Mean	6.96	5.75	5.85	5.75	6.21	−0.76	−0.37	0.55
	S.e.	1.71	1.77	1.90	1.93	2.11	1.78	1.96	2.45
Stocks/T-Bills	Mean	5.44	4.42	4.47	4.44	4.23	−1.21	−0.81	0.17
	S.e.	1.71	1.77	1.90	1.92	2.09	1.77	1.94	2.40

Time-series averages of annualized log k-month returns on portfolios. The countries are sorted by 5-year realized volatility measured at $t-1$ ($Std(\pi_{t-61,t-1})$). The portfolios are re-sorted each month. The sample is 1950–2012. The data are monthly. The sample starts with 10 countries in 1950 and ends with 46 countries in 2012. The unbalanced panel includes Australia, Austria, Belgium, Brazil, Canada, Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Pakistan, Philippines, Poland, Portugal, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Kingdom, the United States, and Venezuela.

to the fifth quintile. For countries in quintile 5, the average lagged inflation rate is 13.77%, compared to only 6.00% in the fourth quintile. Average nominal stock returns increase from 9.67% in quintile four to 14.27% in quintile 5, an increase of 4.60%. By comparison, the difference in realized inflation rates between quintiles four and 5 is closer to 5.40%. Hence, there is a robust though incomplete pass-through of inflation to nominal stock returns.

A more direct test of the rational inattention hypothesis is to sort countries into portfolios based on a measure of realized volatility. Table 7 sorts the entire sample of countries, including those who do not issue local currency bonds, by realized volatility over the past 5 years. The volatility of inflation increases from 1.14% in the first quintile to 7.80% in the last quintile. Volatile inflation goes together with high inflation: Realized inflation also increases from 3.51% in the first quintile to 9.79% in the last quintile. However, in this case, nominal stock returns keep pace with inflation: At the 1-month horizon, there is a 5.52% spread between nominal stock returns in the extreme quintiles, and hence only a -0.76% spread in real stock returns. This is the best evidence that stickiness on the discount rate side is driving our findings. As macro volatility increases, the stickiness disappears altogether. In macroeconomic regimes characterized by high and volatile inflation, nominal stock returns respond almost one for one, even at the 1-month horizon, to variation in expected inflation. This confirms the findings of Liew (1995) who documented that the Fisherian relation between inflation and stock returns is restored when inflation is sufficiently high and volatile. Similarly, for currency markets, Bansal and Dahlquist (2000) report that uncovered interest rate parity works better in high-inflation environments.

As we explained, the model also predicts a positive contemporaneous effect, which appears counterfactual. We also test this implication of the model. If inflation follows a random walk, then the change in inflation is a good measure of inflation surprises. We use the change in inflation $\pi_{t,t+k} - \pi_{t-k,t}$ between month t and $t+k$ to rank countries into portfolios at t, where k denotes the investment horizon. We report average log returns realized between month t and $t+k$ on portfolios of stocks, bonds, and bills. These are not returns on an an implementable investment strategy. The investment horizon varies from 1 month to 12 months, but all the numbers in the tables are annualized. We hold the portfolios constant for k periods. For each of these portfolios, we compute the returns $r_{t,t+k}$ over the next k periods. Because we do not have monthly inflation data for Australia and New Zealand, we exclude these countries. Real bond returns in the last quintile are 9.00% *per annum* lower (s.e. of 0.69%) than those in the first quintile, but real stock returns in the last quintile are 7.46% *per annum* (s.e. of 1.60%) lower than those in the first quintile. At the 1-month horizon, stocks perform only slightly better than bonds in hedging against surprise inflation. At the 3-month horizon, the results look very similar. The difference in real bond returns between portfolio 5 and portfolio 1 is −7.72%, compared with −5.71% for stocks. Again, stocks only provide a small incremental hedge against inflation innovations. Detailed results are in Online Appendix E.

The sticky discount rate model presents a time aggregation challenge for econometricians: The model without the cash flow channel predicts instantaneous positive returns, but negative returns immediately after the revelation of inflation news. After a burst of inflation, the real discount rate drops on day 0, but then immediately starts to increase (on day 1) as agents adjust their inflation expectations. If we had calibrated the sticky information model to daily data, the one-day response would be large and positive, but immediately followed by negative returns the next day, and all days after that, until the effects had dissipated. Hence, it is entirely possible that we fail to detect this effect because it is immediately followed by a negative response in the sticky information model.

4.2 Under-reaction of nominal discount rates

We also consider a model in which stock investors do not have rational expectations, but are learning about the true DGP. When setting the nominal discount rates (i.e., computing $\mathbb{E}_t^{i*}[\sum_{j=1}^{\infty} \rho^{j-1} r_{t+j}^{\$}]$), the marginal stock investor uses an AR(1) process for inflation, specified as: $\pi_t^r = (1-\phi^r)\theta^r + \phi^r \pi_{t-1}^r + u_t^r$, where $0 < \phi^r < 1$ denotes the AR(1) coefficient, while θ^r is the investor's estimate of the unconditional mean of inflation. When aggregated across all stocks, the marginal stock investor also implicitly uses an AR(1) process to project nominal cash flows $\pi_t^c = (1-\phi^c)\theta^c + \phi^c \pi_{t-1}^c + u_t^c$, where $0 < \phi^c < 1$ denotes the AR(1) coefficient, while θ^c is the investor's estimate of the unconditional mean of inflation. To keep the analysis simple, we assume that the real aggregate dividend growth and real stock returns expected by the investors is constant over time: $\mathbb{E}_t^*[r_{t+1}] = \mu_r$ and $\mathbb{E}_t^*[\Delta d_{t+1}] = \mu_d$. As a result, expected nominal returns are given by: $\mathbb{E}_t^*[r_{t+j}^{\$}] = \mu_r + \theta^r + \phi^j(\pi_t - \theta^r)$. We can back out a similar expression for expected nominal dividend growth. Plugging these back into Equation 2 produces this expression for the log price-dividend ratio:

$$pd_t = constant + \frac{(\phi^c - \phi^r)}{(1-\rho\phi^c)(1-\rho\phi^r)}\pi_t, \tag{12}$$

where the last term reflects the time-variation in $\mathbb{E}_t[\sum_{j=1}^{\infty} \rho^{j-1} r_{t+j}]$.

To fix ideas, we start by considering the case in which the cash flow forecast uses the actual DGP. If investors underestimate the persistence of inflation when setting discount rates ($\phi = \phi^c > \phi^r$), then an increase in inflation will increase the stock market valuations. As a result, subsequent real returns will be low. Learning is not an obvious candidate explanation: it is not entirely clear why learning would always lead investors to underestimate the persistence of inflation.[18]

4.3 Extrapolation and over-reaction of nominal cash flows

An alternative explanation could be the overreaction of nominal cash flow forecasts at the firm level to inflation news. This would imply that real cash flow forecasts under the subjective measure $\mathbb{E}_t^*[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d_{t+j}]$ increase in response to inflation in Equation 3. B develops a simple model with nominal cash flow extrapolation that delivers similar implications for real return predictability. Let's return to Equation 12 and assume that the agents are using the right DGP for inflation when setting discount rates. Extrapolation corresponds to ($\phi^c > \phi^r = \phi$). An increase in inflation increases the p-d ratio.

Barberis, Shleifer, and Vishny (1998), Fuster, Hebert, and Laibson (2011); and Hirshleifer and Yu (2013) all study behavioral asset-pricing models in which investors extrapolate fundamentals. Table 8 studies long-term earning forecasts to test the extrapolation hypothesis. We use 3- to 5-year-ahead nominal earnings forecasts from IBES/MSCI, and 10-year-ahead GDP forecasts (year over year growth rate, 12-month ahead) from Consensus economics. The earnings forecasts are obtained by aggregating (value-weighted) across all

18 However, looking at the U.S. experience, Milani (2007) concludes that agents who use adaptive learning would have underestimated inflation persistence until the early 1980s. The perceived degree of persistence then declines again, only to increase in the 1990s. In the baseline panel, the stock return spread between the lowest and the highest quintile is smallest or even switches signs in the 1980s, consistent with the notion that persistence ϕ^r was too low around the world in the 1950s and 1960s, and finally was about right in the 1980s.

Table 8
Long-term earnings and GDP forecasts

Horizon		60-month					
		Low	2	3	4	High	High-low
Panel A: Lagged inflation							
log inflation $\pi_{t,t+60}$							
Sorted	Mean	0.66	1.61	2.24	3.14	6.17	5.51
	S.e.	1.97	1.64	1.50	1.30	3.59	3.26
realized	Mean	1.35	1.82	2.17	2.82	5.11	3.77
	S.e.	0.25	0.25	0.28	0.31	0.55	0.42
Log earnings $\Delta e^{\$}_{t,t+k}$							
Realized	Mean	11.94	10.53	9.94	9.19	14.10	2.16
	S.e.	12.18	7.32	6.59	5.15	6.33	2.24
Forecast	Mean	11.78	11.04	10.78	12.06	13.05	1.27
	S.e.	0.96	1.19	0.98	1.06	0.75	0.53
Log-real earnings $\Delta e_{t,t+k}$							
Realized	Mean	10.59	8.71	7.77	6.37	8.98	−1.61
	S.e.	5.56	3.94	3.52	3.28	2.88	1.43
Forecast	Mean	10.44	9.21	8.61	9.24	7.94	−2.50
	S.e.	0.52	0.63	0.53	0.69	0.62	0.65
Log-real gdp $\Delta y_{t,t+k}$							
Forecast	Mean	2.77	2.69	2.65	3.00	3.59	0.81
	S.e.	0.31	0.11	0.14	0.24	0.68	0.54
Panel B: Lagged inflation deviation from the mean							
Log inflation $\pi_{t,t+60}$							
Sorted	Mean	−5.50	−1.55	−0.77	−0.11	1.01	6.52
	S.e.	10.54	3.13	1.90	1.39	1.17	7.24
Realized	Mean	4.15	2.25	2.19	2.07	2.83	−1.32
	S.e.	0.82	0.28	0.24	0.31	0.34	0.59
Log earnings $\Delta e^{\$}_{t,t+k}$							
Realized	Mean	14.84	10.86	9.78	10.36	10.01	−4.83
	S.e.	17.96	8.31	3.19	4.15	6.10	6.40
Forecast	Mean	13.80	11.72	11.09	10.42	11.41	−2.39
	S.e.	1.87	0.89	1.26	1.05	1.14	1.12
Log-real earnings $\Delta e_{t,t+k}$							
Realized	Mean	10.69	8.61	7.58	8.29	7.17	−3.51
	S.e.	5.75	5.98	1.87	2.63	2.54	2.42
Forecast	Mean	9.65	9.47	8.89	8.35	8.57	−1.07
	S.e.	1.06	0.61	0.75	0.55	0.44	0.92
Log-real gdp $\Delta y_{t,t+k}$							
Forecast	Mean	3.32	2.78	2.60	2.66	3.28	−0.04
	S.e.	1.24	0.21	0.16	0.08	0.34	0.52

Time-series averages of annualized log k-month ahead forecasts on inflation-sorted portfolios. In Panel A, the countries are sorted by year-over-year inflation realized at month $t-1$ ($\pi_{t-12,t}$). In Panel B, the countries are sorted by year-over-year inflation minus 10-year inflation realized at month $t-1$ ($\pi_{t-12,t}-\pi_{t-120,t}$). The GDP forecast is the real 10-year ahead GDP growth rate. The earnings forecast is the 3 to 5 year ahead nominal growth rate. The real earnings growth forecast is obtained by subtracting the rate of inflation over the 60-month forecast period. All growth rates are annualized. The portfolios are re-sorted each month. The sample is 1990–2012. The data are monthly. The sample includes Australia, Germany, Belgium, Brazil, Canada, Denmark, Spain, Finland, France, Greece, Indonesia, Ireland, Israel, Italy, Japan, South Korea, Mexico, Malaysia, Netherlands, Norway, New Zealand, Austria, Philippines, Portugal, South Africa, Sweden, Singapore, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States. The standard errors, denoted "s.e.", were generate by bootstrapping 10,000 samples with replacement.

stocks in the MSCI index. All numbers in the Table are annualized. The standard errors are generated with a parametric correction for autocorrelation, assuming that the data generating process is an AR(1).

In Panel A, we see evidence that the nominal LT-earnings forecasts aggregated by inflation quintile fail to keep up with inflation. As a result, the real forecast growth rate of earnings, obtained by subtracting the realized rate of inflation over the 12-month forecast period, is 250 basis points lower in the highest-inflation quintile, even though the forecast for real GDP growth rate is actually 81 basis points higher in the last quintile. These results suggest stickiness of nominal cash flow forecasts rather than extrapolation. Extrapolation predicts LT-forecasts that are too high in the highest-inflation quintiles. In the first quintile, the forecast is 14 basis points lower than the actual realized earnings growth rate. In the last quintile, the forecast is 104 basis points lower than the realized growth rate.

Panel B looks at portfolios sorted by lagged inflation in deviation from the mean rate of inflation. In this case, there is some evidence to support the notion that investors extrapolate when forecasting inflation dynamics: The real growth forecast in the first quintile falls short of the realized earnings growth by 104 basis points, while it exceeds it by 140 basis points in the last quintile. However, these differences are not statistically significant. In addition, when we focus only on developed countries, the pattern reverses itself and the earnings forecasts are slightly too high in the first inflation quintile.[19]

4.4 Rational expectations models and risk-based explanations

The hypothesis in rational expectations models is that risk premiums are lower in countries with higher inflation than the global average, thus lowering real discount rates $\mathbb{E}_t[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}]$ in Equation 3 decline in response to an increase inflation. 2 ingredients are needed. First, the stock market investors' real discount rate $cov(\mathbb{E}_t[\sum_{j=1}^{\infty}\rho^{j-1}\Delta r_{t+j}],\pi_t^e)<0$ covaries negatively with (expected) inflation π^e and increases the dividend yield when expected inflation declines, producing a negative inflation risk premium: nominal assets provide a fundamental hedge. Investors want to pay for exposure to expected inflation. This force tends to produce a downward sloping nominal yield curve and negative stock-bond correlations.

Second, rational expectation models face the same challenge as sticky information models in accounting for the contemporaneous effect. In this class of rational expectations models, there is no time aggregation issue.[20] As a result, the discount rate effect has to be more than offset by a decrease in current and future expected cash flow growth–the cash flow channel–to be

[19] This evidence is not shown in Table 8.

[20] Recall that in sticky discount rate models, the instantaneous positive effect on stock valuations of an inflation surprise is immediately offset by subsequent decreases in the valuation, as agents update inflation expectations. That is not the case when investors have rational inflation expectations.

consistent with the response of stocks to inflation surprises: $cov(\Delta\pi_{t+1},(\mathbb{E}_{t+1}-\mathbb{E}_t)[\sum_{j=1}^{\infty}\rho^{j-1}\Delta d_{t+j}])<0$.

In a flexible, reduced-form model, Lettau and Wachter (2007) build this second ingredient, the cash flow channel (negative correlation between current dividend growth and expected inflation/inflation innovations), into a reduced form model engineered to match the yield curves as well other moments of bond and stock returns. A model with the cash flow channel, but not the discount rate channel, matches the negative relation between inflation innovations and real stock returns. This model also delivers an upward sloping nominal yield curve and a positive stock-bond correlation.[21] However, a model with both the cash flow and discount rate channel will have trouble producing an upward sloping yield curve and a positive stock-bond correlation. Moreover, it is hard to explain why adverse macroeconomic news about current or future cash flow growth would lower the risk premium in an equilibrium model.[22]

Naturally, there could be multifactor affine models out there that manage to reproduce all of these moments. In addition, there has been interest in regime-switching models. Campbell, Pflueger, and Viceira (2013) and David and Veronesi (2014) develop explanations for the time-variation in the stock-bond correlation. Song (2014) reconciles the upward sloping nominal yield curve with a negative stock-bond correlation in a regime switching model.

4.5 Other explanations

First, in an incomplete markets model, demand for stocks as a hedging device against inflation may drive down the real stock returns that investors demand in equilibrium. In this class of models, inflation volatility determine the demand for stocks as hedges. In the cross-section, we find no evidence of a relation between inflation volatility, measured over 60-month rolling windows, and real stock returns.[23]

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21 Piazzesi and Schneider (2006) show that a negative correlation between expected inflation and future real consumption growth, a feature of the U.S. data, delivers upward sloping nominal yield curves in a standard representative agent dynamic equilibrium model. Bansal and Shaliastovich (2013) extend a version of this model to match moments of bond, stock and currency returns by introducing uncertainty about inflation as an additional state variable. Nakamura et al. (2013) find evidence of inflation spikes during consumption disasters. There is an older literature on this topic. Fama (1981) originally proposed a proxy explanation of the negative correlation between expected inflation and stock returns in the U.S. time series. Fama conjectures that there is a negative relation between the future growth of real activity and the level of expected inflation, as well as a positive correlation between the future growth and expected real stock returns, thus giving rise to a negative correlation between inflation expectations and expected real returns. Geske and Roll (1983) developed a reverse causation version of this argument.

22 A central tenet of modern asset pricing is that the price of risk is counter-cyclical (see Campbell and Cochrane 1999). There is plenty of empirical evidence to support this notion (see Lettau and Ludvigson 2002, Lustig and Verdelhan 2012). In this class of models, expected returns on stocks invariably increase in bad times, when marginal utility growth is high. That delivers a negative covariance between realized stock returns and the pricing kernel, the key to a positive equity premium.

23 In a related strand of the literature, Alvarez, Atkeson, and Kehoe (2002, 2009) develop a Baumol-Tobin model with endogenously segmented markets. Investors incur a fixed costs when participating in asset markets. An increase in expected inflation increases the benefit of participation in asset markets and hence lowers risk premiums. If

Second, lower than expected inflation increases corporate leverage because corporations tend to issue nominal bonds. The credit risk associated with deflation is priced in U.S. corporate bond markets (see Kang and Pflueger 2014). The increase in leverage would lead to higher expected returns on equity in the portfolios of countries with low lagged inflation in deviation from the average. However, it is doubtful that this mechanism is quantitatively important for the value-weighted stock market. In addition, from the perspective of the real debt burden, unanticipated inflation is good news for stocks (see, Gomes, Jermann, and Schmid 2014, contrary to what we find in the data.

Third, money illusion cannot account for our findings. In their classic paper, Modigliani and Cohn (1979) conjectured that stock market investors may use nominal discount rates to price real cash flows. Looking at the U.S. experience, Asness (2000) documents a striking correlation between nominal bond yields and the stock market's earning yields, suggesting that U.S. investors discount real cash flows at a lower rate when nominal interest rates are low. The "Fed model" implies that stocks are expensive in low-inflation environments.[24] We find the opposite relation in a large panel of countries.

5. Conclusion

This paper examined whether local stocks hedge local investors against increases in the cost of the local consumption basket. At each point in time, we consider only the effect of local inflation shocks in deviation from the global average which allows for sharper inference. We conclude that the nominal discount rates uses by local stock market investors are slow to respond to news about the future path of local inflation. There is no comparable evidence of stickiness in the response of the nominal discount rates applied to local bonds and baskets of foreign stocks. The effects of this stickiness on real stock returns are large and economically significant, and quite persistent.

While we cannot rule out a risk-based explanation of our findings, we found little evidence in the data to support this view. Instead, we view our findings as consistent with small departures from rational inflation expectations on the part of stock investors when they set long-run nominal discount rates. When inflation

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inflation is sufficiently high, the neutrality of inflation is restored, in line with our findings for high inflation countries. However, this Baumol-Tobin mechanism cannot explain the asymmetric effect of inflation on equity and bond risk premiums.

24 Several authors have found additional evidence in support of the money illusion hypothesis. Campbell and Vuolteenaho (2004) find that the level of inflation explains a large share of mispricing of the U.S. stock market, consistent with the Modigliani-Cohn hypothesis. In the cross-section of U.S. stocks, Cohen, Polk and Vuolteenaho (2005) also find evidence that stock market investors are subject to money illusion, while Brunnermeier and Julliard (2008) report similar evidence from U.S. housing markets. Piazzesi and Schneider (2008) develop an equilibrium model in which real rate disagreement is driven by money illusion. Using survey data for earnings forecasts and expected inflation, Sharpe (2002) attributes the negative correlation between equity valuations and expected inflation to an increase in the required real return on stocks and a decrease in expected earnings growth that coincide with a rise in expected inflation. In recent work, Bekaert and Engstrom (2010) attribute this U.S. correlation to heightened uncertainty during times of higher expected inflation in the United States.

is highly persistent, these small mistakes impute substantial predictability to real returns, because stocks are long duration assets. More applied theory work is needed in this area to ascertain whether the heterogeneity in stickiness of stock and bond investors' discount rates can be quantitatively attributed fully to either rational inattention, learning about the inflation data generating process, or some other mechanism.

APPENDIX A. Proofs

Proof of Proposition 1:

Proof. In the case of information stickiness, the discount rate component is given by:

$$\mathbb{F}_t^r\left[\sum_{k=1}^{\infty}\rho^{k-1}r_{t+k}^{\$}\right]=(\mu_r+\theta)+\sum_{k=1}^{\infty}\rho^{k-1}(1-\lambda_r)\sum_{j=0}^{\infty}(\lambda_r)^j\phi^{j+k}(\pi_{t-j}-\theta),$$

which can be simplified as

$$\mathbb{F}_t^r\left[\sum_{k=1}^{\infty}\rho^{k-1}r_{t+k}^{\$}\right]=\frac{\theta+\mu_r}{1-\rho}+\sum_{j=0}^{\infty}(\lambda_r)^j(1-\lambda_r)(\pi_{t-j}-\theta)\sum_{k=1}^{\infty}\rho^{k-1}\phi^{j+k},$$

$$=\frac{\theta+\mu_r}{1-\rho}+\sum_{j=0}^{\infty}(\lambda_r)^j(1-\lambda_r)\frac{\phi^{j+1}}{1-\rho\phi}(\pi_{t-j}-\theta).$$

In the case of information stickiness, the aggregate cash flow component is given by:

$$\mathbb{F}_t^c\left[\sum_{k=1}^{\infty}\rho^{k-1}\Delta d_{t+k}^{\$}\right]=\frac{\theta+\mu_q}{1-\rho}+\sum_{j=0}^{\infty}(\lambda_c)^j(1-\lambda_c)(\pi_{t-j}-\theta)\sum_{k=1}^{\infty}\rho^{k-1}\phi^{j+k}$$

$$=\frac{\theta+\mu_q}{1-\rho}+\sum_{j=0}^{\infty}(\lambda_c)^j(1-\lambda_c)\frac{\phi^{j+1}}{1-\rho\phi}(\pi_{t-j}-\theta),$$

where we have used that firm-level real quantity growth is i.i.d. over time. We end up with the following expression for the log dividend price ratio:

$$dp_t=\frac{-k}{1-\rho}+\frac{\mu_r-\mu_q}{1-\rho}+\sum_{j=0}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(\pi_{t-j}-\theta),$$

$$=\frac{-k}{1-\rho}+\frac{\mu_r-\mu_q}{1-\rho}+\frac{\phi(\lambda_c-\lambda_r)}{1-\rho\phi}(\pi_t-\theta)+\sum_{j=1}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(\pi_{t-j}-\theta).$$

■

Proof of Proposition 2:

Proof.

Suppose investor i has a log SDF m_{t+1}^i. m_{t+1}^i is jointly normally generated with $(\Delta d_{t+1}^{i,\$},\pi_{t+1})$. Variances and co-variances are constant. Then the Euler equation of this investor is given by:

$$\mathbb{E}^*\left[\exp(m_{t+1}^i-\pi_{t+1}+\Delta d_{t+1}^{i,\$}+\rho pd_{t+1}^i+k-pd_t^i)|\mathcal{F}_{t-l^r(i)}^r,\mathcal{F}_{t-l^c(i)}^c\right]=1.$$

Expectations w.r.t. inflation and nominal dividend growth are sticky. To forecast inflation, this expert uses $\mathcal{F}_{t-l^r(i)}^r$. To forecast the cash flow, this expert uses $\mathcal{F}_{t-l^c(i)}^c$. We conjecture and verify that

$pd_t^i = A_0^i + A_1^i \phi^{l^r(i)}(\pi_{t-l^r(i)} - \theta) + A_2^i \phi^{l^c(i)}(\pi^i_{t-l^c(i)} - \theta)$ satisfies this Euler equation. All variances and covariances are constant, and end up determining A_0^i. When computing the Euler equation, the expert realizes that she will refresh her expectation of inflation and nominal dividend growth respectively next period with probability $(1-\lambda^r), (1-\lambda^c)$. We plug in our conjecture into the Euler equation, and we find that

$$A_1^i = -\frac{\phi}{1-\rho\phi}, A_2^i = \frac{\phi}{1-\rho\phi}$$

To derive this result, start from the Euler equation,

$$1 = \mathbb{E}^*[\exp(m^i_{t+1} - \pi_{t+1} + \Delta d^{i,real}_{t+1} + \pi^i_{t+1} + \rho p d^i_{t+1} + k - p d^i_t) | \mathcal{F}^r_{t-l^r(i)}, \mathcal{F}^c_{t-l^c(i)}].$$

We conjecture that the log price/dividend ratio is affine: $pd_t^i = A_0^i + A_1^i \phi^{l^r(i)}(\pi_{t-l^r(i)} - \theta) + A_2^i \phi^{l^c(i)}(\pi^i_{t-l^c(i)} - \theta)$. Next, we plug this expression into the Euler equation, which produces:

$$1 = \mathbb{E}^*[\exp(m^i_{t+1} - \pi_{t+1} + \Delta d^{i,real}_{t+1} + \pi^i_{t+1} + \rho(A_0^i + A_1^i \phi^{\tilde{l}^r(i)}(\pi_{t+1-\tilde{l}^r(i)} - \theta) + A_2^i \phi^{\tilde{l}^c(i)}(\pi^i_{t+1-\tilde{l}^c(i)} - \theta))$$
$$+ k - A_0^i - A_1^i \phi^{l^r(i)}(\pi_{t-l^r(i)} - \theta) - A_2^i \phi^{l^c(i)}(\pi^i_{t-l^c(i)} - \theta)) | \mathcal{F}^r_{t-l^r(i)}, \mathcal{F}^c_{t-l^c(i)}],$$

where $\tilde{l}^r(i)$ and $\tilde{l}^c(i)$ represent agent's information about inflation in the next period. Note that $\tilde{l}^r(i) = l^r(i)+1$ with probability λ^r and $\tilde{l}^r(i) = 0$ with probability $1-\lambda^r$; $\tilde{l}^c(i) = l^c(i)+1$ with probability λ^c and $\tilde{l}^c(i) = 0$ with probability $1-\lambda^c$. We need to take expectation across $2 \times 2 = 4$ cases. Take the case in which $(\tilde{l}^r(i), \tilde{l}^c(i)) = (0,0)$. The relevant component of the Euler equation expression is given by:

$$(1-\lambda^r)(1-\lambda^c)\mathbb{E}^*[\exp(m^i_{t+1} - \pi_{t+1} + \Delta d^{i,real}_{t+1} + \pi^i_{t+1} + \rho(A_0^i + A_1^i(\pi_{t+1} - \theta) + A_2^i(\pi^i_{t+1} - \theta))$$
$$+ k - A_0^i - A_1^i \phi^{l^r(i)}(\pi_{t-l^r(i)} - \theta) - A_2^i \phi^{l^c(i)}(\pi^i_{t-l^c(i)} - \theta)) | \mathcal{F}^r_{t-l^r(i)}, \mathcal{F}^c_{t-l^c(i)}].$$

Using the discount rate and cash flow forecast of inflation, we can simplify this part of the Euler equation to a constant K_0, comprised of all the variance/covariance terms, times the component with conditional means:

$$K_0 \cdot \exp(-\phi^{l^r(i)+1}\pi_{t-l^r(i)} + \phi^{l^c(i)+1}\pi_{i,t-l^c(i)} + \rho A_1^i \phi^{l^r(i)+1}\pi_{t-l^r(i)} + \rho A_2^i \phi^{l^c(i)+1}\pi_{i,t-l^c(i)}$$
$$- A_1^i \phi^{l^r(i)}\pi_{t-l^r(i)} - A_2^i \phi^{l^c(i)}\pi^i_{t-l^c(i)}).$$

Likewise, the other cases can also be reduced to a constant K that multiplies the same exponential. As a result, we can represent the entire Euler equation in similar fashion:

$$1 = K \cdot \exp(-\phi^{l^r(i)+1}\pi_{t-l^r(i)} + \phi^{l^c(i)+1}\pi_{i,t-l^c(i)} + \rho A_1^i \phi^{l^r(i)+1}\pi_{t-l^r(i)} + \rho A_2^i \phi^{l^c(i)+1}\pi_{i,t-l^c(i)}$$
$$- A_1^i \phi^{l^r(i)}\pi_{t-l^r(i)} - A_2^i \phi^{l^c(i)}\pi^i_{t-l^c(i)}).$$

Because this formula has to hold for all possible values of $\pi_{t-l^r(i)}$ and $\pi^i_{t-l^c(i)}$, the coefficients on the inflation lags have to be zero:

$$0 = -\phi + \rho\phi A_1^i - A_1^i,$$

$$0 = \phi + \rho\phi A_2^i - A_2^i.$$

The result follows. When we aggregate across all stocks weighted by the fraction of investor updating each period, we end up with the following expression for the the discount rate component of the market (by aggregating $A_1^i \phi^{l^r(i)}(\pi_{t-l^r(i)}-\theta))$:

$$+\sum_{j=0}^{\infty}(\lambda_r)^j(1-\lambda_r)(\pi_{t-j}-\theta)\sum_{k=1}^{\infty}\rho^{k-1}\phi^{j+k},$$

$$=constant+\sum_{j=0}^{\infty}(\lambda_r)^j(1-\lambda_r)\frac{\phi^{j+1}}{1-\rho\phi}(\pi_{t-j}-\theta),$$

and for the cash flow component of the market (by aggregating $A_2^i \phi^{l^c(i)}(\pi^i_{t-l^c(i)}-\theta))$:

$$=constant+\sum_{j=0}^{\infty}(\lambda_c)^j(1-\lambda_c)(\pi_{t-j}-\theta)\sum_{k=1}^{\infty}\rho^{k-1}\phi^{j+k}$$

$$=constant+\sum_{j=0}^{\infty}(\lambda_c)^j(1-\lambda_c)\frac{\phi^{j+1}}{1-\rho\phi}(\pi_{t-j}-\theta),$$

where we have used that the cross-sectional average of π^i_{t+1} equals π_{t+1}. As a result, we get the same expression for the aggregate log dividend/price ratio. ■

Proof of Corollary 2:

Proof. Next, we turn to real log returns. Loglinearization of the real return equation around the mean log price/dividend ratio delivers the following expression for log real returns denoted r (see Campbell and Shiller 1988):

$$\begin{aligned}
r_{t+1} &= \Delta d_{t+1}+\rho pd_{t+1}+k-pd_t,\\
&= \Delta d_{t+1}-\rho\frac{\phi(\lambda_c-\lambda_r)}{1-\rho\phi}(\pi_{t+1}-\theta)+\frac{\phi(\lambda_c-\lambda_r)}{1-\rho\phi}(\pi_t-\theta)\\
&\quad -\rho\sum_{j=1}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(\pi_{t+1-j}-\theta)\\
&\quad +\sum_{j=1}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(\pi_{t-j}-\theta).
\end{aligned}$$

Or, equivalently, the log real return can be expressed as:

$$\begin{aligned}
r_{t+1} &= \Delta d_{t+1}+\rho pd_{t+1}+k-pd_t,\\
&= \Delta d_{t+1}+\sum_{j=0}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(L-\rho)(\pi_{t+1-j}-\theta)\\
&= \Delta d_{t+1}+\sum_{j=0}^{\infty}\frac{(\lambda_r)^j(1-\lambda_r)-(\lambda_c)^j(1-\lambda_c)}{1-\rho\phi}\phi^{j+1}(1-\rho L^{-1})(\pi_{t-j}-\theta).
\end{aligned}$$

■

APPENDIX B. Model of Cash Flow Extrapolation

We use \$ to denote variables expressed in nominal terms. We consider the cum-dividend return on a stock, expressed in dollars:

$$R^{\$}_{t+1} = \frac{P^{\$}_{t+1} + D^{\$}_{t+1}}{P^{\$}_t} = \frac{\frac{D^{\$}_{t+1}}{D^{\$}_t}(1 + PD_{t+1})}{PD_t}.$$

We use pd_t to denote the log price-dividend ratio: $pd_t = p_t - d_t = \log\left(\frac{P_t}{D_t}\right)$, where price is measured at the end of the period and the dividend flow is over the corresponding period. Log-linearization of the nominal return equation around the mean log price/dividend ratio delivers the following expression for log dollar returns denoted $r^{\$}$ (see Campbell and Shiller 1988):

$$r^{\$}_{t+1} = \Delta d^{\$}_{t+1} + \rho p d_{t+1} + k - pd_t,$$

with a linearization coefficient ρ that depends on the mean of the log price/dividend ratio pd: $\rho = \frac{e^{pd}}{e^{pd}+1} < 1$.

By iterating forward on the linearized return equation and imposing a no-bubble condition: $\lim_{j,\infty} \rho^j pd_{t+j} = 0$, we obtain the following expression for the log price/dividend ratio as a function of nominal cash flows and discount rates:

$$pd_t \equiv constant + \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d^{\$}_{t+j}\right] - \left[\sum_{j=1}^{\infty} \rho^{j-1} r^{\$}_{t+j}\right]. \tag{A1}$$

This expression has to hold for all sample paths. By the same token, we also know that a real version of this equation has to hold:

$$pd_t \equiv constant + \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d_{t+j}\right] - \left[\sum_{j=1}^{\infty} \rho^{j-1} r_{t+j}\right]. \tag{A2}$$

We consider a model in which stock investors do not have rational expectations. The stock investor prices stocks by discounting nominal cash flows. By taking expectations under the investor-specific measure, we end up with an expression for the log of the price-dividend ratio:

$$pd_t = constant + \mathbb{E}^{inv}_t \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d^{\$}_{t+j}\right] - \mathbb{E}^{inv}_t \left[\sum_{j=1}^{\infty} \rho^{j-1} r^{\$}_{t+j}\right]. \tag{A3}$$

When setting the nominal discount rates (i.e. computing $\mathbb{E}^{inv}_t \left[\sum_{j=1}^{\infty} \rho^{j-1} r^{\$}_{t+j}\right]$), the marginal stock investor uses an AR(1) process for inflation, specified as:

$$\pi^r_t = (1-\phi^r)\theta^r + \phi^r \pi^r_{t-1} + u^r_t,$$

where $-1 < \phi^r < 1$ denotes the AR(1) coefficient, while θ^r is the investor's estimate of the unconditional mean of inflation. When projecting nominal cash flow growth rates (i.e., computing $\mathbb{E}^{inv}_t \left[\sum_{j=1}^{\infty} \rho^{j-1} \Delta d^{\$}_{t+j}\right]$) the marginal stock investor also uses an AR(1) process, albeit with different parameters :

$$\pi^c_t = (1-\phi^c)\theta^c + \phi^c \pi^c_{t-1} + u^c_t,$$

where $-1 < \phi^c < 1$ denotes the AR(1) coefficient, while θ^c is the investor's estimate of the unconditional mean of inflation.

To keep the analysis simple, we assume that the real aggregate dividend growth and real stock returns expected by the investors is constant over time: $\mathbb{E}^{inv}_t[r_{t+1}] = \mu_r$ and $\mathbb{E}^{inv}_t[\Delta d_{t+1}] = \mu_d$. As a result, expected nominal returns are given by: $\mathbb{E}_t^{inv}[r_{t+j}^{\$}] = \mu_r + \theta^r + \phi^j(\pi_t - \theta^r)$. We can back out a similar expression for expected nominal dividend growth. Plugging these back into Equation A3 produces:

$$pd_t = constant + \frac{\theta^c((1-\phi^c)(1-\rho\phi^r)) - \theta^r((1-\phi^r)(1-\rho\phi^c))}{(1-\rho)(1-\rho\phi^c)(1-\rho\phi^r)} + \frac{(\phi^c-\phi^r)}{(1-\rho\phi^c)(1-\rho\phi^r)}\pi_t, \quad \text{(A4)}$$

Now we turn to the real version of this equation under the actual measure. If we assume that real dividend growth is not predictable under the actual measure ($\mathbb{E}_t[\Delta d_{t+1}] = \mu_d$), then the price/dividend ratio increases in response to inflation. We return to Equation A2, taking expectations under the actual measure in terms of real cash flows and returns:

$$pd_t = constant + \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}\Delta d_{t+j}\right] - \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}\right] = constant - \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}\right]. \quad \text{(A5)}$$

The log dividend yield equals the present discounted value of expected real returns:

$$dp_t = constant + \mathbb{E}_t\left[\sum_{j=1}^{\infty}\rho^{j-1}r_{t+j}\right] = constant + \frac{(\phi^r-\phi^c)}{(1-\rho\phi^c)(1-\rho\phi^r)}\pi_t,$$

where the last equality follows from Equation A4. Under the actual measure, the log real stock returns thus inherit the AR(1) dynamics of inflation.

The slope coefficient in a projection of real returns on inflation ($r_{t+1} = a_r + b_r\pi_t + \epsilon_{t+1}$) can be recovered from:

$$\frac{b_r}{1-\rho\phi} = \frac{(\phi^r-\phi^c)}{(1-\rho\phi^c)(1-\rho\phi^r)},$$

which implies that:

$$b_r = \frac{(\phi^r-\phi^c)(1-\rho\phi)}{(1-\rho\phi^c)(1-\rho\phi^r)}, \quad \text{(A6)}$$

where ϕ equals the actual AR coefficient of π_t.

The contemporaneous response of nominal returns to inflation innovations is given by:

$$r_{t+1}^{\$} = \Delta d_{t+1}^{\$} + \rho\frac{(\phi^c-\phi^r)}{(1-\rho\phi^c)(1-\rho\phi^r)}\pi_{t+1} + k - \frac{(\phi^c-\phi^r)}{(1-\rho\phi^r)(1-\rho\phi^c)}\pi_t,$$

If real dividend growth does not respond to inflation innovations, the slope coefficient in a contemporaneous regression of the nominal returns $r_{t+1}^{\$}$ on π_{t+1}

$$\rho\frac{(\phi^c-\phi^r)}{(1-\rho\phi^c)(1-\rho\phi^r)}$$

The cash flow extrapolation hypothesis implies that $\phi = \phi^r < \phi^c$: The stock investor's cash flow process implies less mean reversion in inflation than the discount rate process. To keep the analysis tractable, we assume that the marginal stock investor implicitly relies on the actual data generating process for inflation when projecting nominal discount rates: $(\phi^r, \theta^r) = (\phi, \theta)$. However, when computing nominal discount rates for nominal cash flows, the marginal stock investor uses $\phi < \phi^c$. The slope coefficient in Equation A6 simplifies to:

$$b_\pi = \frac{(\phi-\phi^c)}{(1-\rho\phi^c)}. \quad \text{(A7)}$$

Higher current (long-run) inflation means lower (higher) subsequent real stock returns, simply because investors extrapolate nominal cash flow growth rates. The regression coefficients for excess returns are identical provided that bond investors use the right inflation process.

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