Durable Goods, Inflation Risk and the Equilibrium Asset Prices

Bjørn Eraker  Ivan Shaliastovich  and Wenyu Wang *

April 2013

Abstract

High inflation predicts a decline in future real consumption and equity cash-flows, which is significantly stronger for durable than for non-durable goods. This suggests that durables is an important channel through which inflation affects long-term economic growth and asset prices. We derive and estimate an equilibrium two-good nominal economy with recursive utility over durable and nondurable consumption and persistent variations in real expected growth rates and expected inflation. Our model can account for the key features of macro data, nominal bond yields and equity prices in durable and nondurable sectors, such as an upward-sloping nominal yield curve, and higher risk premia, volatility and correlations of durable equity returns with expected inflation and bond returns, relative to nondurable equities. The two-good structure, recursive utility and a non-neutral effect of inflation on future growth play the key role to explain these data features.

*Bjørn Eraker (beraker@bus.wisc.edu) and Wenyu Wang (wwang33@wisc.edu) are from the Wisconsin School of Business, University of Wisconsin, Madison. Ivan Shaliastovich (corresponding author) is from Wharton School, University of Pennsylvania, 3620 Locust Walk, Philadelphia, PA 19104. Phone: (215) 746-0005, email: ishal@wharton.upenn.edu. We thank Andrew Abel, Torben Andersen, Ravi Bansal, Geert Bekaert, John Campbell, Anna Cieslak, Max Croce, Urban Jermann, Stijn Van Nieuwerburgh, Mark Ready, Nick Roussanov, Nicholas Souleles, Viktor Todorov, Max Ulrich, Pietro Veronesi, Wei Yang, Amir Yaron, and seminar participants at the 2013 AFA meeting 2012 MFA meeting, 2012 North American Summer Meeting of the Econometric Society, Wharton, the Federal Reserve Board, Kellogg School of Business, University of Warwick, and Wisconsin School of Business for helpful comments.
1 Introduction

In the data, consumption and output of durable goods are more sensitive to economic fluctuations than that of non-durable goods. It is intuitive that consumers would hold off on the purchase of a durable good, such as a car, in response to an adverse economic shock, rather than non-durable goods such as food. In structural economic models, the difference in the exposures of durables and nondurables growth to aggregate risk have important implications for the equilibrium valuations of financial assets, as shown, for example, in Yogo (2006), Gomes, Kogan, and Yogo (2009) and Yang (2010) for the real asset prices in equity markets. In this paper, we focus on the inflation risk channel which arises from a persistent negative impact of expected inflation on future real economic growth (what we call “inflation non-neutrality”). In particular, we show that inflation non-neutrality is very pronounced for durable cash-flows, so that durables are significantly exposed to inflation risk in the data, more so than nondurables. Motivated by this evidence, we estimate an economic model which incorporates persistent fluctuations in expected inflation and expected growth rates in durable and nondurable consumption, and show that it can account for the key features for the macro data, nominal bond yields as well as the differences in equity returns of durable and nondurable good producing firms. We show that two-good structure, early resolution of uncertainty and inflation non-neutrality play the key role to explain these data features.

There are several empirical observations that motivate our two-good nominal model specification. First, shocks to durable consumption growth rate are significantly more persistent than shocks to non-durable consumption growth. This is consistent with the evidence in Yogo (2006) and Yang (2010) and suggests that fluctuations in durable goods constitute an important risk factor for an investor, in addition to non-durables, due to its long-lasting impact on the economy. Second, we document that long-term durable goods growth is more sensitive to shocks in inflation than non-durable growth. In particular, we show that higher inflation has a more adverse impact on future real consumption of durables and on future real cash-flows of durable-goods producing firms, relative to the consumption of non-durable goods and cash-flows in non-durable goods sectors. For example, the slope coefficient in the regression of future cumulative non-durable consumption growth on current inflation is -0.86 at a one-year horizon, and it uniformly decreases in absolute value with the horizon to -0.16 at five years. For durable growth, the inflation slope coefficient is
-0.94 at a one-year horizon. It increases in absolute value to -1.18 at three years at which point it is almost three times as large as the corresponding coefficient in non-durable consumption regressions, and it finally decreases to about -0.93 at a five-year horizon. While inflation being a bad news for future nondurable consumption is consistent with previous studies (see e.g. Bansal and Shaliastovich (2013) and Piazzesi and Schneider (2006)), the evidence for a negative impact of inflation on durable cash-flows is novel, and suggests that durable goods constitute an important source for the inflation premium in the economy that impacts the valuation of financial assets. Finally, we show that movements in the nominal yields predict future real consumption growth of durable goods, and the predictability is stronger for durables than for non-durable goods. These findings are consistent with Erceg and Levin (2006) who document that a monetary policy shock in interest rates has an impact on consumer durables spending several times larger than on other expenditures, and complement an earlier evidence in Yang (2010) that durable consumption growth is strongly predictable by the price-dividend ratio on the aggregate stock market. In all, these empirical findings motivate the specification of our economic model which directly introduces durable and nondurable consumption and a non-neutral effect of inflation on real durable and nondurable growth.

Our economic model is based on a nominal two-good extension of the long-run risks specification of Bansal and Yaron (2004). The key ingredients of our model include the recursive utility over durable and nondurable goods, persistent fluctuations in expected growth rates, and non-neutral effect of expected inflation on future consumption. In the benchmark model, investors are concerned about the fluctuations in the realized and expected consumption growth rates of non-durable and durable goods and the realized and expected inflation. Specifically, the negative shocks in expected consumption of durables and nondurables and positive shocks in expected inflation represent bad states for the investor, so the market prices of expected growth risks are positive and the market price of expected inflation risk is negative. The compensation for the expected nondurable and durable consumption risks and expected inflation risk determine the risk premia on the financial assets. In particular, we show that the model-implied risk premia on real bonds can be positive, so that the real term structure becomes upward sloping, as real bonds hedge the fluctuations in expected consumption of nondurables but are risky with respect to durable risks. In contrast, the real term structure is always downward sloping in one-good specifications of the model. The prices of nominal bonds are further affected by the interaction of expected
inflation with real growth, in addition to these real channels. Nominal bond prices fall and nominal yields rise at times of high expected inflation, which are bad states of the economy as they signal low growth of future durable and nondurables consumption. This leads to a positive inflation premium on nominal bonds, a significant amount of which, we show, arises through the durable channel. Finally, we provide a parsimonious model of the equity dividends in durable and nondurable producing sectors as levered claims on durable and nondurable consumption, respectively. We show that as durable consumption is more persistent and more sensitive to inflation, this makes equity returns for durable firms to be more exposed to risks in expected durable growth and expected inflation. In the model, durables are riskier than nondurables, and further, they react more negatively to shocks in inflation and correlate more positively with returns on bonds relative to nondurable equities.

We estimate the model to further validate its economic channels and disentangle the contribution of its economic inputs. Our model of the macro-economy is based on a VAR(1) model of the three unobserved expected growth components. We estimate this model using Bayesian methods for sampling on the posterior of the parameter space. Our benchmark estimation is a two-stage estimation of the model. In the first stage, we estimate the model parameters and extract the latent states that govern the dynamics of macro variables using only the time series of observable macro variables. In the second step, we estimate the preference parameters using nominal bond yield data and calibrate the dividend leverage parameters for the equities. Thus, the estimation of macro dynamics is independent of the equilibrium model specification and is based only on the observed macro data. Hence, the implications for the term structure and equities can be viewed as effectively “out-of-sample.”

We find that our macroeconomic model captures the observed macroeconomic data very well. Expected growth rates are estimated to be persistent with an autocorrelation of 0.40 for expected non-durable growth, 0.95 for durable growth, and 0.93 for inflation. Our estimates of the autocorrelation of expected nondurable growth and expected inflation are similar to Piazzesi and Schneider (2006) and are somewhat lower than in Bansal and Shaliastovich (2013), who find more persistent dynamics of expected growth states using the information in macroeconomic forecasts and yields, in addition to the realized macroeconomic variables. Consistent with our OLS evidence, expected inflation shocks have a negative impact on non-durable consumption, and a significantly larger and more permanent impact on durable consumption. In-
Indeed, the estimated VAR(1) loading of expected non-durable consumption on the lag of expected inflation is -0.06, and it is about twice as large and is highly statistically significant for expected durables. The inflation impact on future growth of durables is further magnified at longer frequencies due to a high persistence in the underlying expected states.

In the second step, we estimate the underlying preference parameters. We follow a standard co-integration approach in Ogaki and Reinhart (1998) to estimate the intra-temporal elasticity of substitution using the equilibrium relationship between the user cost of durable goods and the consumption of nondurables and durables. In our sample, this regression yields an estimate of the elasticity of 0.81, which agrees very well with the findings in the literature. We choose the remaining preference parameters by minimizing the mean-squared error (MSE) calculated from the one and five year model implied and historical yield data. At quarterly frequency, the estimated inter-temporal elasticity of substitution is 2.2 and the risk aversion coefficient is 21.5. This parameter configuration implies preference for early resolution of uncertainty, and are consistent with the estimates in the literature; see e.g. Bansal and Shaliastovich (2013), Hasseltoft (2012), Doh (2010).

We next consider the equilibrium implications of the model for the bond and equity markets. In the model, the implied real term structure is U-shaped: it is downward sloping from 1.86% to 1.82% from the maturities from one to three years, and becomes upward sloping and goes up to 1.90% at a ten year horizon. Over the short-maturities, the nondurable consumption risks dominate the risk premia on real bonds, so the resulting real term structure is downward sloping. Over the long run, the persistent durable channel takes over and makes the real yield curve upward sloping. Due to a positive inflation premium, the nominal term structure is upward sloping at all the maturities. Unconditionally, our model matches perfectly the levels of one-year and five-year nominal yields of 6.25% and 6.83%, respectively, and the fit to three-year yield of 6.62% is nearly exact as well. In the model, a positive slope of the nominal term structure is due to a positive inflation premium, and we find that a significant portion of this premium comes through the durable channel. Given our estimates of the persistence of the expected states and the preference parameters, restricting the specification to a one nondurable good economy decreases the spread from 60 basis points to 10 basis points. Similarly, removing a negative feedback of expected durables to expected inflation makes the nominal term structure essentially
flat. Further, we find that in the data, short term interest rates load positively on the expected non-durable growth and the expected inflation, and negatively on the expected durable growth. In our benchmark model, the signs and magnitudes of the bond loadings match the data quite well. Indeed, the slope coefficients on expected non-durable growth is 2.65 in the data compared to 2.41 in the model. The slope is 3.7 and 4.00 on expected inflation in the data and in the model, respectively, and it is -1.71 on expected durables in the data relative to -0.61 in the model. These loadings, we show, cannot be explained in the restricted versions of the model to one non-durable consumption good, or in the case of expected utility.

In the model, as in the data, durable equities are riskier and thus require higher risk premium compensation despite the fact that the dividend leverage parameter is higher for nondurables. Indeed, in our calibration, durable equity premium is 6.9% relative to 4.6% for the nondurables and 5.1% for the average market, which compares well to the estimates in the data of 7.1%, 5.6% and 6.0%, respectively. High riskiness of durable equities also leads to a higher unconditional volatility of stock returns and lower levels of the price-dividend ratio, which, we show, the model can match very well. Finally, as both bond and equity prices fall in high expected inflation times, our model predicts that excess stock returns should have a negative correlation with inflation and a positive correlation with bond returns, and this effect is more pronounced for durable portfolios which are more exposed to inflation risk. These model predictions are supported empirically. In the data, the correlation of excess returns with shocks in expected inflation is -0.43 for the durable equities, relative to -0.32 for nondurables and -0.23 for the average market. In the model, this correlation is -0.27 for the durables which is higher in absolute value than -0.21 for the nondurable returns. For stock and bond returns, the correlation of excess nominal stock return in durable portfolio with a two-year excess nominal bond returns is 0.53 in the data, relative to 0.39 for nondurables and 0.32 for the market. In the model, the unconditional correlations are equal to 0.57 for durables, 0.16 for non-durables and 0.33 for the market, which are close to the estimates data. Similar to the nominal bond markets, the recursive utility, two-good structure and inflation non-neutrality for durable growth play an important role to match the level and the signs of these effects in the data.

We consider additional implications of the model for the long-maturity yields to gain information about the long-term properties of the economy. In our benchmark
case, the nominal term structure is upward sloping and flattens out at long maturities, reaching 7.90% at thirty years and 8.18% at a hundred years. Similarly, the real term structure is upward-sloping after three years, reaches 1.99% at thirty years and flattens out at 2.0% at a hundred years. Following Bansal and Lehman (1997), Alvarez and Jermann (2005) and Hansen and Scheinkman (2009), we consider the decomposition of the pricing kernel into its transitory martingale and a dominant component, and find that in our economy, the infinite-horizon nominal bond risk premium is about 22% of the maximum nominal risk premium while, the infinite-horizon real bond risk premium is about 1% of the maximum real risk premium. The long-term bond premia are relatively small, consistent with arguments in Alvarez and Jermann (2005) and Koijen, Lustig, Nieuwerburgh, and Verdelhan (2010).

The empirical evidence in our paper is connected to a large literature which documents the interactions between inflation, bond and equity prices. Early empirical works, such as Fama (1975) and Fama and Schwert (1977), show that nominal bond yields move approximately one-to-one with inflation. Fama and Schwert (1977) document that stock returns are contemporaneously negatively correlated with shocks to expected inflation, and Bekaert and Wang (2010) provide an international evidence for a negative co-movement of stock returns with expected inflation. The evidence on correlations of stock returns with inflation is closely related to the proxy hypothesis in the money demand models of Fama (1981) and Kaul (1987), who argue that when inflation and expected growth are negatively correlated, then inflation will proxy for future real output, which gives rise to a negative relationship between stock returns and inflation. Finally, while most of the studies consider aggregate stock prices, our findings for a difference in inflation exposures across durable and nondurable sectors are consistent with Boudoukh, Richardson, and Whitelaw (1994) who consider cross-sectional differences in industry exposures to expected inflation risk and document that in the data, highly cyclical industries, such as manufacturers of durable goods, tend to have more negative expected inflation betas than less cyclical firms.

In terms of the economic modeling, our approach follows the long-run risk paradigm of Bansal and Yaron (2004). Bansal and Shaliastovich (2013) consider an economy with a single nondurable consumption good, and focus on the equilibrium implications of the time-varying volatility of consumption and inflation for the fluctuations in bond

---

1The so-called Fisher hypothesis, that interest rates move one-to-one with inflation is consistent with a neutral role of money. A more recent empirical literature challenges this finding, see Coorey (2002) for a literature review.
risk premia. Hasseltoft (2012) shows that the long-run risks model can successfully account for the key features of the bond and aggregate equity markets. Eraker (2006) and Piazzesi and Schneider (2006) consider related versions of the nominal economy and study the implications for the equilibrium nominal yields. All the model specifications above are based on a single consumption good model specification. Yang (2010) specifies a real model with a nondurable and durable consumption growth, and shows that the persistent fluctuations in durable consumption go a long way to match the key moments of aggregate stock markets in the data. Guo and Smith (2010) provide similar evidence for the long-run risks in durable consumption in the U.K. financial markets. Branger, Dumitrescu, Ivanova, and Schlag (2011) study the implications of the fluctuations of the relative share movements of the two goods for the equilibrium volatilities and the risk premia in the financial markets. Colacito and Croce (2013) consider a two-good recursive utility economic structure in the international context to address the foreign exchange anomalies. Yogo (2006) uses the stochastic discount factor implied by the recursive preference over the two goods to explain the cross-section of asset returns, while Lustig and Verdelhan (2007) use this framework to capture currency returns. Gomes et al. (2009) addresses the implications of durability of goods for the equity return in the context of equilibrium production economy.

Our paper is connected to the earlier literature on multiple consumption goods, including Eichenbaum and Hansen (1990), Dunn and Singleton (1986), and Ogaki and Reinhart (1998). While most of this literature is based on additive utility specifications, Dunn and Singleton (1986), using term structure data, find evidence against a specification of expected non-separable utility over durables and non-durables. Further, while most of the literature, including our paper, relies on homothetic preferences, Pakos (2011), Pakos (2005) and Ready (2010) argue for non-homothetic preferences to capture the interaction between the two goods in the data.

Our paper is part of the recent literature attempting to provide structural economic explanation to the asset markets. The examples of the alternative economic channels include habit specifications in Wachter (2006) and Bekaert and Grenadier (2001), ambiguity in Ulrich (2013), monetary policy shock in Gallmeyer, Hollifeld, Palomino, and Zin (2009) and beliefs heterogeneity in Ehling, Gallmeyer, Heyerdahl-Larsen, and Illeditsch (2012). Further, our model features constant risk premia, asset-price volatility and constant correlations between returns. A number of recent
works consider time-variation in the correlations between bond and stock returns, and attribute these variations to the fluctuations in time-varying covariance between inflation and real economy (Campbell, Sunderam, and Viceira, 2012), fluctuations in the volatility and risk premia (Hasseltoft (2009), Bekaert and Engstrom (2010)), learning and non-linearities in the dynamics of real growth and inflation (David and Veronesi, 2012) or liquidity factors (Bekaert, Baele, and Inghelbrecht, 2010).

The paper is organized as follows. The next section presents an empirical evidence on nondurable and durable consumption and dividend growth rates in durable and nondurable sectors, and their link to inflation. In Section 3 we discuss the economic model and the solution to equilibrium bond and equity prices. Section 4 presents the empirical results for the model estimation and model implications for the term structure and equities. Section 5 considers additional model implications, while Section 6 concludes the paper. Model derivations are provided in the Appendix.

2 Empirical Motivation

2.1 Data

We collect quarterly data on nominal expenditures on non-durable goods and services, nominal durable good expenditures, and non-durable and durable good price levels from the Bureau of Economic Analysis (BEA) from 1963Q1 to 2007Q4. The data are adjusted by the BEA to remove seasonality at quarterly frequencies. We deflate aggregate nominal service flows by the appropriate price levels and divide by the total population to obtain real per-capita service flows. Since the BEA only reports the year-end durable good stock levels, we back out the quarterly durable good stock level using the depreciation and expenditure data as in Yogo (2006). We further collect the nominal bond price data on zero-coupon U.S. Treasuries and price and dividend data for the broad market index and for the equity portfolios.

\footnote{Bils (2009) and Bils and Klenow (2001) argue that the CPI inflation series released by the Bureau of Labor Statistics is mis-measured because consumers shift purchases of durable goods items from old to higher quality new models; see also the Boskin Commission Report (Boskin, Dubberger, Gordon, Griliches, and Jorgenson (1996)) and references therein. In our implementation, as in Piazzesi, Schneider, and Tuzel (2007), we use non-durable consumption as the numeraire and use the inflation rate for non-durable goods.}

\footnote{We checked that our results are robust to alternative seasonality adjustment procedures.}
of firms in nondurable and durable sectors. The construction of durable and nondurable portfolios follows Gomes et al. (2009), and uses the benchmark input-output accounts in BEA to identify industries whose final demand has highest value added to personal consumption expenditures on nondurable goods and services (nondurable sector portfolio) and personal consumption expenditures on durable goods (durable sector portfolio). The details of construction of the portfolios are provided in Gomes et al. (2009).

Table 1 presents basic descriptive statistics for our aggregate macroeconomic data. The mean of non-durable consumption growth over the sample is 2.2%, annualized, while the average growth of stock of durable goods is 4.3%. The inflation rate in nondurable goods is equal on average to 4.2%, and its standard deviation is 1.3% relative to 0.9% for both non-durable and durable consumption growth rates. As shown in Table 1, while both nondurable and durable consumption growth rates are persistent in the data, the shocks in consumption growth of durables are significantly more long-lasting: the first-order autocorrelation of durable consumption growth of 0.78 is much larger than 0.33 of non-durables and is similar to 0.84 of inflation. The persistence of shocks in durable consumption growth decays slowly over time, as shown in Figure 1. For durable consumption growth and inflation rate, the autocorrelation coefficients remain positive and significant beyond the ten quarters horizon, while the autocorrelation coefficient of non-durable consumption growth becomes insignificant at about one year. This evidence of high persistence in durable consumption growth is consistent with the findings in Yogo (2006) and Yang (2010).

As shown in Table 1, real consumption growth rates and inflation exhibit a modest negative correlation at quarterly frequency: the correlations of inflation rate with nondurable consumption growth is equal to -0.27, and it is -0.21 for durable consumption. Interestingly, in the data inflation has a significant long-run impact on future consumption, which we discuss in the next section.

### 2.2 Economic Growth and Inflation

The key empirical motivation for our paper is that in the data, long-term real economic growth rates, such as of aggregate consumption and sector portfolio dividends, respond negatively to inflation, and such a non-neutrality of inflation for future growth is significantly more pronounced for durable relative to nondurable goods. To measure
the long-term impact of inflation on future growth, we project an average cumulative future consumption growth on the current inflation rate:

\[ \bar{g}_{t\rightarrow t+h} = \text{const} + b_h \pi_t + \text{error}_{t\rightarrow t+h}, \]

where \( \bar{g}_{t\rightarrow t+h} \) stands for an average future cumulative real growth in nondurables or durables over \( h \)-quarter horizon, and \( \pi_t \) is the inflation rate. We report the predictability evidence for nondurable and durable consumption in Table 2. As shown in the Table, the slope coefficients are all negative and significant, which suggests that high current inflation has a non-neutral and adverse effect on future real growth.

While our findings of inflation non-neutrality for nondurable consumption are consistent with Piazzesi and Schneider (2006) and Bansal and Shaliastovich (2013), the novel evidence in this paper is that inflation is also non-neutral for durable consumption, and furthermore, the inflation effect on durables is much stronger than that for non-durables. Indeed, the slope coefficient in the regression of future non-durable consumption on inflation is -0.86 at a one-year horizon, and it uniformly decreases in absolute value with the horizon to -0.16 at five years. The \( R^2 \)s in these regressions decrease from 19% at one year to 3% at five years. For durable growth, the inflation slope coefficient is -0.94 at a one-year horizon. It increases in absolute value to -1.18 at three years at which point it is almost three times as large as the corresponding coefficient in non-durable consumption regressions, and it finally decreases to about -0.93 at a five-year horizon. The \( R^2 \)s in durable consumption regressions reach about 25% at three- to five-year horizons. That is, while high inflation is bad news for both non-durable and durable consumption, it affects future consumption of durables much more than that of non-durables. Intuitively, because durable purchases are long-lasting, they respond more significantly to aggregate price fluctuations relative to non-durables which are consumed in the same period.

We obtain similar evidence for inflation non-neutrality using the data on real dividends of durable and non-durable equity portfolios. Overall, the dividend data are much noisier than consumption; the volatility of dividends is ten times higher than the volatility of aggregate consumption. Further, dividends exhibit significant seasonality at high frequency. To mitigate these issues, we aggregate dividends to an annual horizon and perform our analysis at an annual frequency. Table 3 shows the projections of average cumulative dividend growth rates on inflation. Future durable dividend growth respond negatively to news of higher inflation: the slope coefficient
is -2.56 at a one-year horizon, -1.23 at three years and it drops to -0.49 at a five-year horizon. As dividends are quite noisy and the regression frequency is annual, the estimates are less precise than in the consumption regressions, and are not significant beyond three years. The effect of inflation for nondurable sector dividends is also negative but is much weaker relative to durables. Indeed, the slope coefficient for nondurable dividends is -0.33 at one year, -0.08 at three years and it is 0.17 at five years. None of these coefficients are significant, and the $R^2$s do not exceed 1%. We further show the results for the projection of the future market dividends on current inflation. The estimates of the projection coefficient for the market dividends fall in between those for the durable and nondurable sectors. The slope coefficient is negative and decreases in absolute value from -0.96 at a one year horizon to -0.18 at five years.

For robustness, we use alternative measures of firm output to corroborate our findings of a non-neutral effect of inflation on future growth. For example, the slope coefficient in the regression of one-year future real sales growth on inflation is -1.24 (0.31) for a durable portfolio relative to -0.54 (0.24) for nondurables, and the $R^2$ of 28% for durables is almost three times as high as that for nondurables. At a three-year horizon, the slopes are -0.64 (0.21) for durable portfolio and -0.58 (0.19) for nondurables; after three years the estimates are insignificant. Similar results obtain using the firm earnings as a measure of the cash flow. Overall, these findings are consistent with the evidence in Boudoukh et al. (1994), who document that the output growth in highly cyclical industries (e.g., those involved in manufacturing of durable goods) tends to be more negatively correlated with inflation relative to less cyclical firms (such as those which provide necessities).

We further find that long-term movements in real growth are anticipated by the bond prices in the data, and durable consumption is more predictable by the interest rates than nondurable consumption. Specifically, we regress the cumulative average consumption growth on a nominal 3-month interest rate. As shown in Table 2 for non-durable consumption an increase in yield predicts a fall in non-durable consumption growth up to a three-year horizon, and the effect becomes insignificant afterwards. The $R^2$ in the regressions is 15% at a one-year horizon, and it drops to zero after three years. On the other hand, interest rates significantly and negatively forecast future durable goods growth up to and beyond five years. The regression slope coefficient is -0.27 at a one-year horizon, -0.24 at three years, and -0.13 at five
years, respectively, and the $R^2$s increase from 16% at one-year to 20% at two and three years before dropping to 10% at a five-year horizon. Interestingly, the response of future durable growth to interest rates can not be attributed entirely to the inflation component in nominal yields. Indeed, as shown in a lower panel of Table 2, in multivariate regressions of future durables growth on both the short rate and the inflation rate, the slope coefficient on yields remains negative and significant up to three years, while the slope coefficient for nondurable consumption is insignificant after two years. In Section 4, we use direct estimates of the expected inflation and expected consumption growth rates and provide further evidence that interest rates in the data anticipate movements in future durable consumption, controlling for the effect of expected inflation. This empirical evidence on a higher response of future durable consumption to interest rates relative to consumption of nondurables is consistent with Erceg and Levin (2006), who document that a monetary policy shock in interest rates has an impact on consumer durables spending that is several times larger than its impact on other expenditures. These findings further complement an earlier evidence by Yang (2010) who find that the durable consumption growth is strongly predictable by the price-dividend ratio on the aggregate stock market, and much more so relative to the nondurable consumption.

To sum, our empirical results suggest that inflation impacts long-term real growth of aggregate consumption and dividends, and its effect is more pronounced for durable goods than for nondurables. Further, nominal interest rates contain additional information about future durable consumption beyond inflation component. These empirical findings motivate our structural asset-pricing model which explicitly introduces durable and nondurable consumption and a non-neutral effect of inflation on real growth, that can operate both through the durable and nondurable goods channel. We use our equilibrium model to understand the implications of these economic channels on the pricing of nominal bonds and equities in durable and nondurable sectors, and their link to aggregate macroeconomic variables and each other.
3 Model Setup

3.1 Preferences and Stochastic Discount Factor

We specify an infinite-horizon, discrete-time endowment economy where investors’ preferences over the durable and non-durable goods are described by the Kreps and Porteus (1978), Epstein and Zin (1989) recursive utility function:

\[ U_t = \left[ (1 - \beta)u_t^{1 - \frac{1}{\psi}} + \beta \left( E_t U_{t+1}^{1 - \gamma} \right)^{1 - \frac{1}{\psi}} \right]^{1 - \frac{1}{\psi}}, \tag{2} \]

where \( U_t \) is the life-time utility function, \( u_t \) is the intra-period consumption aggregator, \( \beta \) is the subjective discount factor, \( \psi \) is the elasticity of intertemporal substitution (IES), and \( \gamma \) is the relative risk aversion coefficient. For ease of notations, we define \( \theta = (1 - \gamma)/(1 - 1/\psi) \). Note that when \( \theta = 1 \), that is, when \( \gamma = 1/\psi \), the recursive preferences collapse to a standard CRRA expected utility.

In our economy, the agent derives utility from non-durable consumption \( C_t \) and a service flow from durable goods, which, following the literature, is assumed to be proportional to the stock of durables \( S_t \) (see e.g. Ogaki and Reinhart (1998); Yogo (2006); Yang (2010)). The intra-period nondurable and durable consumption aggregation takes a constant elasticity of substitution form, and thus can be expressed in the following way:

\[ u(C, S) = \left[ (1 - \alpha)C^{1 - \frac{1}{\epsilon}} + \alpha S^{1 - \frac{1}{\epsilon}} \right]^{\frac{1}{1 - \frac{1}{\epsilon}}}. \tag{3} \]

The preference weight \( \alpha \in [0, 1] \) determines the relative importance of durable consumption: with \( \alpha = 0 \) the economy collapses to a model with a single perishable good. Parameter \( \epsilon \) captures the intra-temporal elasticity of substitution between the two goods. High values of \( \epsilon \) indicate that the two goods can be easily substituted by the agent, while small values for \( \epsilon \) reflect complementarity between the two goods.

\[ \text{We use a standard specification of preferences which features a homothetic utility function and constant preference weights to the consumption goods. Pakos (2005) and Ready (2010) consider the extension of the model to non-homothetic preferences and show its implications for the equilibrium asset prices.} \]
As in standard in the literature, we assume that the nondurable consumption good is fully consumed within the period. On the other hand, the stock of durable goods accumulates over time through the purchases of durable goods $E_t$ net of the depreciation at the rate $\delta$:

$$S_t = (1 - \delta)S_{t-1} + E_t.$$  \hfill (4)

The representative agent in the economy trades in frictionless good and financial asset markets to maximize the utility function in (2), subject to the standard budget constraint. The equilibrium solution to the economy is described in Yogo (2006). In particular, the equilibrium stochastic discount factor, valued in the units of non-durable consumption, can be expressed in terms of the relative share of non-durable goods $Z_{t+1}$, consumption growth of non-durables $C_{t+1}/C_t$ and the return on total wealth $R_{c,t+1}$:

$$M_{t+1} = \beta^\theta \left( \frac{Z_{t+1}}{Z_t} \right)^{\frac{\theta}{1 - \frac{1}{\psi}} (\frac{1}{\psi} - \frac{1}{\xi})} \left( \frac{C_{t+1}}{C_t} \right)^{-\frac{\theta}{\psi} R_{c,t+1}^{\theta-1}}.$$ \hfill (5)

In the above expression, the relative share of non-durable consumption of the agent $Z_t$ is defined as,

$$Z_t = \frac{C_t}{C_t + Q_t S_t},$$ \hfill (6)

where $Q_t$ is the user cost of durable goods equal in equilibrium to the marginal utility of durable to non-durable good consumption:

$$Q_t = \frac{u_{st}}{u_{ct}} = \frac{\alpha}{1 - \alpha} \left( \frac{S_t}{C_t} \right)^{-\frac{1}{\xi}}.$$ \hfill (7)

The return $R_{c,t+1}$ captures the return on the total wealth portfolio (consumption asset) of the investor, whose dividends each period are equal to the basket of non-durable and durable good consumption, $C_t + Q_t S_t$. The consumption return is not the same as the stock market return as the total consumption of the agent is much larger than the dividends on the stock market. We solve for the endogenous consumption
asset applying a standard Euler condition which can be used to price any asset in the economy, including the return on the wealth portfolio:

\[ E_t M_{t+1} R_{t+1} = 1. \]  

(8)

As shown in equation (6), the sensitivity of the stochastic discount factor to the fluctuations in relative share of non-durables, nondurable consumption growth and the wealth return are pinned down by the preference parameters. In a single nondurable good economy, \( Z_t \equiv 1 \), and we obtain a standard expression for the stochastic discount factor, derived in Epstein and Zin (1991):

\[ M_{t+1}^{Nondur} = \beta^\theta \left( \frac{C_{t+1}}{C_t} \right)^{-\frac{\phi}{\psi}} R_{c,t+1}^{\theta-1}, \]  

(9)

where \( R_{c,t+1} \) pays off the nondurable consumption each period. Relative to a one-good economy, the specification with two goods gives rise to an additional risk factor which captures the fluctuations in the consumption of durable goods, and further, the cash-flows on the wealth portfolio of the agent are now determined by both the non-durable and durable consumption.

Finally, note that our current model solution is specified in real terms using non-durable consumption as a numeraire. To obtain solutions for the nominal prices, denote \( \Pi_t \) the dollar price of one unit of nondurables. Then, we can price nominal payoffs expressed in dollars using a nominal version of the Euler equation in (8) written under the nominal stochastic discount factor \( M_{t+1}^\$ \),

\[ M_{t+1}^\$ = M_{t+1} \frac{\Pi_t}{\Pi_{t+1}}. \]  

(10)

3.2 Economy Dynamics

Denote \( g_t \) the vector of macroeconomic variables which includes non-durable log consumption growth, \( \Delta c_t = \log (C_t/C_{t-1}) \), non-durable log inflation rate, \( \pi_t = \log (\Pi_t/\Pi_{t-1}) \), and log growth rate of a stock of durables, \( \Delta s_t = \log (S_t/S_{t-1}) \). The
dynamics of $g_t$ is specified exogenously, and incorporates a time-variation in the ex-pected growth rates:

$$g_{t+1} = \mu_g + x_t + \Sigma_g \eta_{t+1},$$  \hspace{1cm} (11)

where $\eta_{t+1}$ is a three-dimensional vector of independent Gaussian shocks, $\mu_g$ is the vector of unconditional means of the variables, and $\Sigma_g$ is the volatility matrix. The three-dimensional state vector $x_t$ captures the persistent variations in expected growth of non-durable consumption, expected inflation and expected growth of durable good consumption. We model $x_t$ as an unrestricted VAR(1) process:

$$x_{t+1} = \Pi x_t + \Sigma_x u_{t+1},$$  \hspace{1cm} (12)

where $\Sigma_x$ is the volatility matrix and $u_{t+1}$ is a three-dimensional vector of independent Gaussian innovations which are assumed to be uncorrelated with short-run news $\eta_{t+1}$. The matrix $\Pi$ captures the persistence of the expected growth rates of non-durable and durable consumption and expected inflation, and the feedback effects between these states. In particular, the empirical evidence in Section 2 suggests that the macroeconomic variables in vector $g$ are persistent, and inflation has a non-neutral and adverse effect on future consumption growth of nondurable and durable goods. These features of the data can be captured by our expected growth specification above through positive elements on the diagonal of the persistence matrix, and by allowing for a negative feedback effect of past expected inflation on future expected growth (i.e., $\Pi(1, 2) < 0$ and $\Pi(3, 2) < 0$).

Our dynamics for the expected growth rates extends typical model specifications in the literature. The original specification in Bansal and Yaron (2004) features a real economy with a single non-durable good. Bansal and Shaliastovich (2013), Eraker (2006), Hasseltoft (2012) and Piazzesi and Schneider (2006) consider a nominal economy with a single consumption good and specify a bi-variate model for the dynamics of expected consumption and expected inflation. In the two-good real economy of Yang (2010), the dynamics of durable and non-durable consumption are driven by a single expected growth component. Our nominal two-good economy specifications allows for separate and interdependent processes in expected non-durable consumption growth, the expected durable consumption growth, and the expected inflation rate, which we estimate in a flexible way in the data.
Finally, it is important to note that for parsimony, the volatilities of all of the shocks in our model are constant, so that, following a log-linearization of the model solution, the model-implied asset-price volatilities and the asset risk premia are constant as well. The key focus of our paper is on understanding the importance of the durable versus nondurable good channel for the unconditional levels of prices and the risk premia, hence, we choose to shut down the fluctuations in the volatilities to highlight the effects of the time-varying expected growth rates. It is straightforward to extend the model to allow for the time-variation in the volatility of consumption and inflation to generate fluctuations in risk premia, as shown in Bansal and Shaliastovich (2013) and Hasseltoft (2012).

3.3 Equilibrium Model Solution

To obtain closed-form analytical solutions to the asset prices, we log-linearize the relative share process, so that in equilibrium the fluctuations in $z_t = \log Z_t$ are driven by the linear combination of the variables in $g_t$:

$$
\Delta z_{t+1} = \log \frac{Z_{t+1}}{Z_t} \approx \chi (\Delta q_{t+1} + \Delta s_{t+1} - \Delta c_{t+1}) \\
= \chi \left(1 - \frac{1}{\epsilon}\right) (i_s - i_c)' g_{t+1},
$$

(13)

where $i_c$ and $i_s$ pick out non-durable and durable consumption growth from vector $g_t$, and the parameter $\chi \in (0, 1)$ is an approximating constant equal to the average expenditure on durables in the economy, $\chi = \frac{QS}{QS+QC}$. This parameter captures the importance of durable goods in the economy. In particular, setting $\chi = 0$ our model reduces to a one-good nondurable consumption economy.

To solve the model, we further log-linearize the return to the wealth portfolio (see Appendix for the details). In our model solution, the equilibrium log price-

---

$^5$Empirically, the log-linearization of the the relative share is very accurate, as the share of durables is quite stable in the data. Indeed, the correlation between the log-linearized and the actual growth rate in $z_t$ is 0.997, and the standard deviations of the two are virtually identical. Given the entertained parameter values, we do not expect the log-linearization to have first-order implications on prices and risk premia.
consumption ratio on the wealth portfolio, $pc_t$, then becomes a linear function of the economic states $x_t$:

$$pc_t = A_0 + A'_x x_t.$$  

(14)

Using the Euler equation for the consumption asset, we obtain that the price-consumption loadings satisfy:

$$A_x = \left(1 - \frac{1}{\psi}\right) (I - \kappa_1 \Pi')^{-1} ((1 - \chi) i_c + \chi i_s),$$  

(15)

where $\kappa_1 \in (0, 1)$ is the log-linearization coefficient whose solution is provided in Appendix A. When the intertemporal elasticity of substitution $\psi$ is above one, the price of the consumption claim generally increases with positive news about expected non-durable or durable consumption. Furthermore, because positive expected inflation shocks forecast a decline in future real growth, the loading on the expected inflation is negative. The intuition for these results naturally follows from a standard one-good specification of the model of Bansal and Yaron (2004), where for $\psi > 1$ the substitution effect in the economy dominates the wealth effect, so that equity prices increase in good times of high expected growth.

The real stochastic discount factor, expressed in units of non-durable numéraire, can be written in terms of the fundamental states and shocks in the economy in the following way:

$$m_{t+1} = m_0 + m'_x x_t - \lambda'_g \Sigma_g \eta_{t+1} - \lambda'_x \Sigma_x u_{t+1},$$  

(16)

where $m_x$ captures the loadings of the stochastic discount factor on the expected growth components, and $\lambda_g$ and $\lambda_x$ are the market prices of immediate and expected growth risks. To gain further intuition on the sources and compensation for the aggregate risks in the economy, we decompose the stochastic discount factor loadings and the market prices of risks into the components related to non-durable and durable consumption state variables. The discount factor loading on the expected growth satisfies:

$$m_x = -\left(\frac{1}{\psi}(1 - \chi) + \frac{1}{\epsilon \chi}\right)i_c + \chi \left(\frac{1}{\epsilon} - \frac{1}{\psi}\right)i_s.$$  

(17)
The two components in brackets capture the loadings of the stochastic discount factor on the expected non-durable consumption and expected durable consumption, respectively. When $\chi = 0$ the specification reduces to a one good non-durable model, and the discount factor loading is equal to the negative of the reciprocal of the IES. With durable goods, both the inter-temporal and intra-temporal elasticities of substitution determine the sensitivity of the discount factor to the underlying economic states.

In a two-good economy, similar to a one-good economy, the loading on expected non-durable consumption is negative, so that an increase in expected consumption of non-durables leads to an expected decline in the marginal utility of the agent. On the other hand, when $\epsilon < \psi$ the loading on the expected durable consumption is positive: when two goods are relatively hard to substitute, an expected increase in durable consumption for a given expected consumption of non-durables actually results in an increase in the expected marginal utility of the agent. Thus, with complementarity between the two goods, the shocks in expected durable and expected non-durable consumption have opposite effects on the drift of the stochastic discount factor.

In a similar way, we can decompose the market prices of expected growth and short-run risks in the economy:

$$\lambda_z = \left( \gamma (1 - \chi) + \frac{1}{\epsilon} \chi \right) i_c + \left( \gamma - \frac{1}{\epsilon} \right) \chi i_s,$$

$$\lambda_x = (1 - \theta) \kappa_1 A_x.$$  

The market prices of short-run nondurable and durable consumption risks $\lambda_z$ depend on preference parameters and the importance of durables in the agent’s total consumption, and for typical parameter values these market prices of risk are positive. With preference for early resolution of uncertainty, investors are further averse to the fluctuations in expected durable and non-durable consumption which have positive market prices of risks. Indeed, for high value of an inter-temporal substitution the value of the wealth portfolio relative to consumption drops when either durable or non-durable growth is expected to decline (see equation 15), so that negative shocks to expected consumption of nondurables or durables are associated with high marginal utility of investor. This effect on marginal utility is magnified by the persistence of the shocks as fluctuations in expected growth are perceived to be long-lasting by the investors. Hence, relative to a one-good economy where only the risk to expected nondurables is priced, with multiple goods the shocks to expected durables
also contribute to the risk compensation on the assets, which can be significant given a high persistence of durable consumption in the data.

Due to a non-neutral effect of expected inflation on future growth, the market price of the expected inflation risks is non-zero as well. In particular, as high expected inflation is bad news for future consumption, the market price of the expected inflation risks is negative when agents have preference for early resolution of uncertainty. Notably, the non-neutrality of expected inflation operates both through the non-durable and durable consumption good channels: in the data, inflation is bad news both for future non-durable and durable consumption. The actual magnitude of the inflation risk compensation then depends on the strength of inflation non-neutrality on future growth of nondurables and durables, the persistence of the state variables and the preference parameters.

Finally, note that the recursive utility structure which disentangles the inter-temporal elasticity of substitution $\psi$ from the coefficient of the risk aversion $\gamma$ plays a significant role for the signs and magnitudes of the market prices of risks. Specifically, a positive market price for expected consumption risk and a negative market price of expected inflation risk obtain only when agents have preference for early resolution of uncertainty ($\gamma > 1/\psi$). With a preference for a late resolution of uncertainty, the market prices of expected growth risks switch sign, while under the expected utility ($\gamma = 1/\psi$), the market prices of expected durable and non-durable consumption and expected inflation risks are all equal to zero: $\lambda_x = 0$. In this case, only the short-run innovations in consumption are priced.

### 3.4 Equilibrium Bond Prices

Using the solution for the stochastic discount factor in (16), we can characterize equilibrium prices of bond and equity claims in the model. We show main results and intuition below, and present the computational details in the Appendix.

In a multi-good economy, there are various ways to define a real risk-free asset, which depends on the choice of the basket of goods to be delivered in the future and the payoff numeraire. For our benchmark analysis, as in Yang (2010), we consider a real bond which delivers one unit of nondurables in the future, and the price of the
bond is expressed in units of nondurable consumption. Then, the price of the bond with \( n \) periods to maturity \( P_{t,n} \) satisfies a standard Euler equation:

\[
P_{t,n} = E_t M_{t+1} P_{t+1,n-1}.
\] (19)

In our model, the equilibrium log bond prices \( p_{t,n} = \log P_{t,n} \) are linear in the economic states,

\[
p_{t,n} = -B_{0,n} - B_{x,n}'x_t,
\] (20)

and the solutions to the bond loadings \( B_{0,n} \) and \( B_{x,n}' \) depend on model and preference parameters and are provided in the Appendix.

To highlight the intuition for the bond prices, consider first the solution to the one-period risk-free rate:

\[
y_{t,1} = \text{const} - m_{x,t}'x_t.
\] (21)

Following our discussion of the stochastic discount factor in a previous Section, the one-period risk-free rate responds positively to news about expected non-durable consumption, and negatively to news about expected durable consumption if \( \epsilon < \psi \). That is, as in a standard one nondurable consumption good model, risk-free rates increase at times of high expected growth of nondurables. However, a positive shock in expected durables implies that the relative share of nondurable consumption is expected to decline, so when the two goods are hard to substitute, the current value of a unit of nondurable consumption in the future goes up and thus the equilibrium risk-free rates fall. Similar intuition applies for the equilibrium loadings for the longer-term bonds.

The sensitivities of bond yields to economic states determine the magnitudes of the bond risk premia and the shape of the yield curve. Consider the excess log return on buying an \( n \) month bond at time \( t \) and selling it next period as an \( n - 1 \) period bond:

\[
rx_{t+1,n} = -p_{t,n} + p_{t+1,n-1} + p_{t,1}.
\] (22)
The expected excess return on \( n\)-period bonds is given by the covariance of the discount factor with the excess bond return:

\[
E_t r_{t+1,n} + \frac{1}{2} \text{Var}_t r_{t+1,n} = -\text{Cov}_t (m_{t+1}, r_{t+1,n-1}) \\
= -B'_{x,n-1} \Sigma_x \Sigma'_x \lambda_x.
\] (23)

The bond risk premia capture the contribution of the expected non-durable consumption risk, expected durable consumption risk, and risks in expected inflation, so that the expected excess return on bonds depends on bond sensitivity \( B_{x,n} \), and the market compensation for these risks, \( \Sigma_x \Sigma'_x \lambda_x \). A standard result in a single-good economy is that the real bonds hedge news in expected consumption: the price of a real bond goes up when expected consumption is low, so that the real bond premium and hence the slope of the real term structure are negative (see Campbell, 1986).

In a two-good economy, as we discussed above, a real bond is still a hedge to the risks in expected consumption of nondurables, but it is now risky with respect to the fluctuations in expected durable growth, which has a positive market price of risk and thus contributes positively to the bond risk premium and the slope of the real term structure. The total effect on the bond risk premium and the resulting slope of the term structure depends on the magnitude and persistence of expected growth risks and the preference parameters.

The equilibrium price of nominal bonds and nominal bond risk premia are derived in an analogous way to the real ones in (20)-(23) using the solution to the nominal stochastic discount factor. In particular, in addition to a contribution from expected nondurable and durable growth risks, a significant component of the nominal bond risk premium now comes from the expected inflation shocks. Indeed, consider a Fisher-type equation for nominal bonds:

\[
y^s_{t,n} = y_{t,n} + E_t \pi_{t \to t+n} - \frac{1}{2} n \text{Var}_t \pi_{t \to t+n} + \frac{1}{n} \text{Cov}_t (m_{t \to t+n}, \pi_{t \to t+n}),
\] (24)

where \( \pi_{t \to t+n} \) and \( m_{t \to t+n} \) denote the \( t \) to \( t+n \) multi-period inflation rate and stochastic discount factor, respectively. First, as nominal bonds pay in nominal dollar terms, an increase in expected inflation directly raises nominal yields and decreases nominal bond prices. Further, when inflation is non-neutral and impacts future real growth, it also affects nominal yields through an inflation premium component, given by the covariance of the stochastic discount factor and inflation. Specifically, when high ex-
pected inflation predicts a persistent decline in expected real growth in the economy, the inflation premium is positive and increasing at long maturities, which leads to a positive bond risk premium and a positive slope of the term structure for the nominal bonds. In a single-good economy, the inflation premium arises due to the interaction between expected inflation with future non-durable consumption growth, as discussed in Piazzesi and Schneider (2006) and Bansal and Shaliastovich (2013). With multiple goods, however, the inflation non-neutrality also arises through a persistent negative covariation of expected inflation with expected durable consumption, which opens up an additional channel for the inflation premium. As the durable growth is persistent and significantly affected by the inflation risk, the inflation premium through the durable consumption can have a significant effect on the level of the nominal bond risk premium and the slope of the nominal term structure, relative to a one-good economy.

Finally, note that in the expected CRRA utility, market prices of expected durable and non-durable risks, and expected inflation are all equal to zero. Therefore, up to Jensen’s inequality term, all the bond risk premia are zero, and the term structure of interest rates is flat. Further, recall that all the shocks in our economy are homoscedastic, so that the risk premia do not vary over time.

### 3.5 Equilibrium Equity Prices

To derive model implications for equities, we consider a very parsimonious representation of the cash-flows in durable and nondurable sectors:

\[
\begin{align*}
\Delta d_{dur,t+1} &= \mu_{dur,d} + \phi_d \Delta s_{t+1}, \\
\Delta d_{nd,t+1} &= \mu_{nd,d} + \phi_{nd} \Delta c_{t+1},
\end{align*}
\]

(25)

where \(\Delta d_{dur,t+1}\) and \(\Delta d_{nd,t+1}\) represent the real log growth rates of the dividends in the durable and nondurable sectors, respectively. Following Abel (1999), each equity represents a levered claim on the corresponding consumption, and the dividend leverage parameters \(\phi_d\) and \(\phi_{nd}\) capture the dividend exposure to the aggregate consumption. Intercept parameters \(\mu_{dur,d}\) and \(\mu_{nd,d}\) are adjusted to yield average dividend growth equal to the appropriate average consumption growth. For parsimony, we do not entertain dividend-specific innovations independent from the fundamental
consumption shocks. In addition to the durable and nondurable sectors, we consider an aggregate market portfolio, and set its dividend growth rate $\Delta d_{m,t+1}$ equal to the weighted average of the dividend growth rates in nondurable and durable sectors with a weight parameter $\chi$, so that $\Delta d_{m,t+1} = \chi \Delta d_{dur,t+1} + (1 - \chi) \Delta d_{nd,t+1}$.

We solve for the equilibrium asset valuations in nondurable and durable sectors and for the market in an analogous way to the price of the wealth portfolio using the the Euler equation (8). The equilibrium solutions to the equity price-dividend ratios are linear in the economic state variables, and are given by,

$$pd_{i,t} = H_{i,0} + H'_{i,x} x_t,$$

for $i = dur, nd$ and $m$. Similar to the price-consumption ratio in (15), the price-dividend ratios load positively on expected consumption of durables and nondurables, and negatively on expected inflation. The magnitudes of loadings depend on the model and preference parameters, such as the intra- and inter-temporal elasticities of substitution, persistence of the state variables and the dividend leverage parameters $\phi_i$.

To gain further intuition on pricing the equity claims, it is useful to consider a standard forward solution to the equity innovation:

$$r_{i,t+1} - E_t r_{i,t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \kappa_{1,i}^j \Delta d_{i,t+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \kappa_{1,i}^j r_{i,t+j-1}$$

$$= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \kappa_{1,i}^j \Delta d_{i,t+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \kappa_{1,i}^j y_{t+j-1,1},$$

where $\kappa_{1,i}$ is the portfolio-specific log-linearization coefficient, and the last equation follows from the first one because in our model the risk premia are constant, so that the expectations of future equity returns, up to a constant, are equal to the expectations of future risk-free rates $y_{t+j,1}$. Thus, in our economy, the shocks in equity returns are explained by the the movements in the current and future equity cash-flows and the equilibrium risk-free rates. Positive shocks to expected aggregate consumption increase future equity cash-flows, and thus will generally increase equity prices for high values of the IES. On the other hand, as expected inflation is bad news for future dividend cash-flows, equilibrium returns drop with positive news about expected
inflation. Thus, our model generates a negative co-movement of shocks to equity returns and expected inflation. Further, recall that equilibrium nominal bond prices fall when expected inflation rises. This implies that in our model, equity returns co-move positively with nominal bond returns. The magnitudes of these equity return correlations with inflation and bond returns depend on the amount of the expected inflation risk in dividend cash-flows, and, given our empirical evidence, are expected to be more pronounced for durable portfolios relative to nondurables and the market. Indeed, durable dividends are a levered claim on durable consumption, which is persistent and quite exposed to expected inflation shocks relative to nondurable consumption. Hence, in equilibrium, durable equity returns have higher exposure to expected inflation risk: other things being equal, they fall more with positive expected inflation shocks and correlate more negatively with bond returns than the returns on non-durable portfolio and the market.

The differences in risk exposures across nondurable and durable equities have direct implications for the level of the equity risk premium and the volatility of the asset prices. The equilibrium equity risk premium reflects the risk compensation for expected nondurable and expected durable consumption growth, expected inflation, as well as the immediate shocks in consumption and inflation:

\[
E_t r_{i,t+1} - y_{t,1} + \frac{1}{2} Var_t r_{i,t+1} = -\text{Cov}_t (m_{t+1}, r_{i,t+1}) \\
= \kappa_{1,i} H'_{i,x} \Sigma_x \Sigma_x' \lambda_x + \phi'_{i} \Sigma_g \phi'_{g} \lambda_g. \tag{28}
\]

As durable equities are more sensitive to expected durable and expected inflation risk, they require a higher unconditional risk premium relative to nondurables. Similarly, higher exposure to expected durable and expected inflation risk also leads to a higher volatility of asset prices and returns in the durable sector relative to nondurables and the market.

It is important to note that the key economic intuition which underlies the above model implications relies on the persistent interaction between expected inflation and expected economic growth rates of nondurable and durable goods. In this case, our implications for the stock and bond correlations are closely related to the "proxy hypothesis" in the money demand models of Fama (1981) and Kaul (1987), who argue that when inflation and expected growth are negatively correlated, then inflation will proxy for future real output, which gives rise to a negative relationship between stock
returns and inflation. In our model, the inflation channel operates through inflation non-neutrality for both future nondurable and nondurable consumption growth, and is magnified due to the persistent fluctuations in the expected growth risks. For simplicity we abstract from other economic channels, such as fluctuations in risk premia and volatility, which can also play a significant role for the co-movements of stock returns with inflation and bond prices. For example, Bekaert and Engstrom (2010) show the importance of a positive link between expected inflation with real uncertainty and stock market risk premia to account for the co-movement of stock prices and expected inflation in the data. Hasseltoft (2009) underscores the role of the time-varying uncertainty channel and risk premia fluctuations on bonds and stocks, while David and Veronesi (2012) discuss the implications of learning and non-linearities in the dynamics of real growth and inflation to account for these empirical facts.

To sum, our model, which features durable and nondurable consumption and inflation non-neutrality for future growth, delivers a range of testable implications for the prices on nominal bonds and equity in durable and nondurable sectors. In the next section, we estimate the model and evaluate its equilibrium implications.

4 Empirical Results

4.1 Estimation Approach

Our empirical evaluation of the economic model is carried in several stages. In the first stage, we estimate the model parameters and extract the latent states that govern the dynamics of the economy in equations (11)-(12) using the time series of nondurable consumption growth, durable consumption growth and nondurable inflation.\footnote{Modigliani and Cohn (1979) and Campbell and Vuolteenaho (2004) propose an alternative behavioural explanation for these empirical facts in the form of inflation illusion.} As using macro data alone does not allow us to identify preference parameters, given the first-stage estimates of the macro dynamics, we estimate preference parameters in the second step using the data on nominal bond and durable good prices. Finally,\footnote{We do not use the data on dividends in durable and nondurable sectors. The dividend data are quite noisy and only available at annual frequency, and do not add much information to estimate model parameters and states.}
we calibrate the two dividend leverage parameters to match the key features of the equity data in nondurable and durable sectors. Thus, our estimation of the economy dynamics is independent of the structural model specification and is based only on the observed macro data. This is economically appealing because 1) the implications for the term structure and equities are effectively “out-of-sample” and subject only to the choice of the few preference and dividend leverage parameters; 2) the estimation of the macroeconomic model and the extraction of economic states is not affected by a possible mis-specification of the economic model; and 3) such an approach allows us for an easier comparison of alternative models keeping the fundamental macroeconomic dynamics unchanged. It is important to note, however, that ignoring asset-price information in the estimation of macro parameters and states comes at a cost, since it is hard to estimate precisely small and persistent components in the expected growth dynamics using macro data alone.

4.2 Estimation of Macro Model

We carry out our first stage of estimation using Bayesian Markov-Chain-Monte-Carlo methods under uninformative (uniform) priors. The Gaussian likelihood function for the economy dynamics in (11)-(12) is standard and is computed using Kalman filtering techniques; all the estimation details are provided in the Appendix. The advantage of Bayesian MCMC Kalman filtering is that we recover estimates of the unobserved latent state-variables, \( \hat{x}_t \), and the model parameters, as well as their posterior distributions which can be used to construct standard errors and confidence intervals.

The top panel of Table 4 reports the parameter estimates of our macroeconomic model. Overall, the estimated model matches very well the persistence in the observed macroeconomic variables in the data and its decays with the horizon, as shown in Figure 1. Consistent with our earlier findings, expected durable consumption and expected inflation are more persistent than expected non-durable growth: the implied first-order autocorrelation of expected non-durable growth is 0.40, relative to 0.95 for durable and 0.93 for inflation. Our estimates of the autocorrelation of expected non-durable growth and expected inflation are similar to Piazzesi and Schneider (2006) who also estimate the economy dynamics using only the macroeconomic variables. Bansal and Shaliastovich (2013) focus on time-variation in macroeconomic volatil-
ities and bond risk premia and find more persistent dynamics of expected growth states using the information in macroeconomic forecasts and yields, in addition to the realized macroeconomic variables.

Consistent with our empirical evidence in Section 2, in the estimated macro model the expected inflation shocks have a negative impact on expected non-durable consumption and a significantly larger and more permanent impact on expected durable consumption: the estimated VAR(1) loading of expected non-durable consumption on the lag of expected inflation is -0.06, relative to -0.11 for expected durables. The estimated coefficient is borderline insignificant for nondurable growth, but is highly statistically significant for durable consumption. Because of a high persistence in the underlying states, the inflation impact on future growth is further magnified at longer frequencies. To highlight multi-horizon interaction between the expected growth rates and expected inflation, we show impulse response functions for the three shocks on Figure 2. As can be seen from the Figure, shocks to expected inflation are very persistent and significantly affect future economic growth. While positive shocks to expected inflation lower both nondurable and durable growth in the future, the negative impact of inflation is much stronger at all the horizons and much more long lasting for expected durable growth than for expected growth of non-durables, which confirms our earlier findings in Table 2.

Finally, Figure 3 shows the estimates of the expected nondurable consumption, expected consumption of durables and expected inflation, alongside with time series of the underlying macroeconomic data. Overall, our macroeconomic model captures well the dynamics of macroeconomic variables in the data, and filtered states track closely data realizations.

### 4.3 Estimation of Preference Parameters

In the first stage of estimation, we obtain the macroeconomic model parameters and the time series of latent expected growth variables. This step does not allow us to identify the preference parameters $\delta, \psi, \gamma$ and $\epsilon$ and the relative importance of durables $\chi$. We estimate these parameters using the data on durable good prices and nominal yields.
Specifically, we follow the co-integration approach in Ogaki and Reinhart (1998) and Yogo (2006) to estimate the intra-temporal elasticity of substitution $\epsilon$ using the equilibrium relationship between the user cost of durable goods $Q_t$ and the consumption of nondurables and durables. The user cost of durable goods $Q_t$ is equal to the rental price of durables, and thus satisfies the following condition:

$$Q_t = P_t^d - (1 - \delta)E_{t+1}P_{t+1}^d,$$

where $P_t^d$ is the purchase price of durables. This equation can be used to empirically measure the user cost $\hat{Q}_t$ in the data. Further, from the intra-temporal optimality condition in (7) we obtain that the (log) user cost is proportional to the difference between log durable and nondurable consumption levels, where the proportionality coefficient is the inverse of the intra-temporal elasticity of substitution $\epsilon$. Hence, subject to the measurement error in user cost observations, we obtain:

$$\hat{q}_t = \frac{1}{\epsilon}(s_t - c_t) + error_t.$$  

This condition allows us to recover the elasticity of substitution parameter from the regression of the log user cost on the difference in log durable and nondurable consumption. In our sample, this regression yields an estimate of $\epsilon = 0.81(0.07)$, which agrees very well with the estimates in the literature. For example, Yogo (2006) finds the elasticity to be 0.79 (0.08); using a shorter sample from 1951 to 1983, Ogaki and Reinhart (1998) report the estimate of 1.17 (0.10), and Piazzesi et al. (2007) also obtain the estimate close to one for housing.\footnote{This econometric approach relies on the assumption of homothetic preferences. With non-homothetic preferences, Pakos (2011) shows that such an estimate of intra-temporal elasticity of substitution is biased upwards, but still remains below one.} Note that in the context of these models, the regression residual has an interpretation of the measurement noise in constructing the user cost in the data. Alternative interpretations for this residual arise in the extensions of the benchmark model to durable good adjustments costs or durable good demand shifters, which lead to an additional wedge in the user cost equations (7) and (30).\footnote{In an earlier draft of our paper we considered time-varying preference weights and specified an exogenous process for $\alpha$ in equation (8). This model extension did not materially affect the main conclusion of the paper for the role of inflation non-neutrality for durable goods, so for simplicity we shut down this channel in this paper and leave it for future research.}
Next, we fix parameter $\chi$, which captures the average relative expenditure on durable goods, to its sample average of 15%. For identification purposes, we fix the subjective discount factor at 0.996. We choose the remaining preference parameters $\psi$ and $\gamma$ by minimizing the mean-squared error (MSE) calculated from the one and five-year model implied and historical yield data. That is, let $Y_t^{data}$ denote the vector of one and five-year yield observed in the data, and let $Y_t$ be the equilibrium yields in the model. We estimate the preference parameters $\psi$ and $\gamma$ by minimizing the squared pricing errors:

$$
\min_{\gamma, \psi} \sum_{t=1}^{T} (Y_t - Y_t^{data})'(Y_t - Y_t^{data}).
$$

(31)

The estimates of the preference parameters are reported in Table 4. To compute the standard errors on the preference parameters, we use parametric bootstrap procedures to account for the first-step estimation error of the macroeconomic model. At quarterly frequency, the estimated inter-temporal elasticity of substitution is 2.2 and the risk aversion coefficient is 21.5. Notably, the risk aversion coefficient is estimated very imprecisely, which reflects the fact that it is hard to estimate accurately persistent risks from the macroeconomic data alone: a small decrease in the estimated persistence of durables and/or inflation would require a substantial increase in the risk aversion to match the slope of the term structure.

### 4.4 Implications for Bond Prices

The model implications for nominal yields are reported in Table 5, while Figures 4 and 5 plot the time-series of the short rate and the term spread in the data and in the estimated model. Unconditionally, our model matches perfectly the levels of one-year and five-year nominal yields of 6.25% and 6.83%, respectively, and the fit to three-year yield of 6.62% is nearly exact as well. The volatilities of nominal yields are somewhat lower in the model (e.g., 1.95% in the model relative to 2.77% in the data for a one-year yield) which reflects the challenge in estimating precisely the persistent states in the macroeconomic data alone. Generally, the model-implied yields track the observed yields in the data quite well, as shown in Figures 4 and 5. Some of the noticeable deviations of the model predictions to the data include the mid-eighties,
where interest rates peaked significantly above what is predicted by our model, as well as the recent episode in early and late 2000s, where the yields in the data were below the model predictions. Note that our model abstracts from interest rate shocks or changes in the monetary policy regimes which can improve the fit of the model to the bond prices, as discussed in Gallmeyer et al. (2009), Bansal and Zhou (2002), Baele, Bekaert, Cho, Inghelbrecht, and Moreno (2012) and Bikbov and Chernov (2008). For simplicity, we also shut down the fluctuations in risk aversion and uncertainty, so the bond risk premia in our economy are constant; Bekaert, Engstrom, and Xing (2009), Wachter (2006) and Bansal and Shaliastovich (2013) discuss the implications of the time-variation in risk premia for the equilibrium bond prices.

Table 5 shows additional conditional implications of the model which we obtain by regressing a short nominal rate on the three filtered expected growth states. In the data, short term interest rates load positively on the expected non-durable growth and the expected inflation, and negatively on the expected durable growth. In our benchmark model, the signs and magnitudes of the bond loadings match the data quite well. Indeed, the slope coefficients on expected non-durable growth is 2.65 in the data compared to 2.41 in the model. The slope is 3.7 and 4.00 on expected inflation in the data and in the model, respectively, and it is -1.71 on expected durables in the data relative to -0.61 in the model. These findings in the data are consistent with our earlier evidence for the predictability of future durable consumption growth by the yields (see Table 2): nominal yields anticipate changes in the future durable growth with a negative sign, controlling for the expected inflation. In the model, a negative response of yields to expected durable consumption is an important equilibrium implication which depends, among other things, on the magnitudes of elasticity of substitution parameters and the underlying preference structure. Indeed, as we discuss below, the negative response of yields to expected durable growth shocks cannot be obtained in a one good economy, or under the restriction of the preferences to power utility.

To highlight the role of the durable channel and the recursive utility for the nominal term structure, we first remove durable goods from the preferences of the agent by setting their relative weight $\chi$ to zero. It is important to note that we keep the estimated dynamics of the macroeconomic variables the same as estimated in Section 4.2, so all the changes in equilibrium asset prices are driven only by the change in the preference structure. In the recursive utility model specification based on a single non-durable good, the model can still generate an upward sloping term structure,
but the term spread (12 basis points) is much smaller than in the data and in the
benchmark model (58 basis points). This suggests that in our estimated model, a
significant component of a positive risk premium on nominal bonds in the benchmark
model arises due to the negative impact of expected inflation on the agent’s con-
sumption of durable goods. Without the durable consumption in the utility of the
agent, the one good version of the model can still deliver a sizable nominal bond risk
premium if we allow the risk aversion coefficient to increase to about 100, consistent
with Piazzesi and Schneider (2006) who also need a large risk aversion coefficient to
magnify the inflation premium from the nondurable consumption channel. However, a single good economy cannot replicate a negative loading of short term rates on
expected durable growth: this loading is equal to zero at any risk aversion parameter.
That is, a single-good model cannot capture an interaction between yields and the
expected durable consumption in the data.

To highlight the importance of recursive preference structure, we report the equi-
librium implications for nominal yields in the expected CRRA utility case with two
goods, or with one nondurable consumption good. Under power utility, the market
prices of expected growth risks are all zero, so the risk premia on bonds are zero, up
to Jensen’s variance term. As shown in Table 5, the implied nominal term structure
is flat and somewhat downward sloping both in one- and two good economy specifi-
cations. The levels and volatilities of the implied risk-free rates are much higher than
in the data, which constitutes a well-known risk-free rate puzzle. Further, while in
a one-good economy the expected durables do not impact the short term rates, the
CRRA economy with durable goods leads to a positive equilibrium loading on the
expected durable growth. Now the elasticity of intertemporal substitution \( \psi = 1/\gamma \) is
below the elasticity of intra-temporal substitution \( \epsilon \), so bond yields respond positively
to a shock to expected durable growth. This is counterfactual in the data.

Finally, we consider the importance of inflation non-neutrality for the equilibrium
bond prices. In general, it is not easy to identify separately the effect of expected in-
flation on future durable and nondurable growth, as in our estimation the persistence
and scale matrices are unrestricted to capture full dynamic interaction between all
the three state variables. To evaluate the contribution of durable inflation channel in
a simple and convenient way, we just zero out the coefficient in persistence matrix \( \Pi \)

\[10\] Bansal and Shaliastovich (2013) and Hasseltoft (2012) estimate a one-good model specification
using jointly the macroeconomic and asset-pricing moments, and find more persistent dynamics of
expected states and lower values of the risk aversion parameter.
which measures the response of durable expected consumption to the lag of expected inflation (i.e., \( \Pi(3, 2) \)), and we refer to this case "inflation neutrality for durables". Similarly, the case of "inflation neutrality for nondurables" is obtained by zeroing out the coefficient \( \Pi(1, 2) \) which captures the response of nondurable expected consumption to the lag of expected inflation. Notably, such "inflation neutrality" only holds at one-quarter horizon: for longer maturities, the effect of expected inflation on expected growth rates is not zero, e.g. due to the dynamic interactions between durable and nondurable expected growth rates. Nevertheless, this exercise goes a long way to disentangle the impact of expected inflation on nondurable and durable growth separately. Table 5 shows that inflation non-neutrality for durable growth plays a key role to generate upward sloping nominal term structure: when durable expected consumption does not respond to the past expected inflation, the slope of the nominal term structure is only 10 basis points. On the other hand, there is no significant change in the nominal term structure under the inflation neutrality for nondurable growth. The slope of the nominal term structure is 60 basis points, similar to the benchmark case.\(^{11}\) Thus, in our estimated model, durable good channel plays a significant role to explain nominal term structure.

In our empirical implementation we focus on nominal yields as the data on real yields is not available for long maturities. To provide further intuition on the economic channels, we consider model implications on equilibrium real bonds which pay a unit of nondurable consumption. As shown in Table 6 in our benchmark model, the real yield curve is nearly flat and U-shaped: it is downward sloping from 1.86% to 1.82% from 1 to 3 year maturities, and becomes upward sloping and goes up to 1.90% at 10 year horizon. As we discussed in Section 3, the non-durable expected consumption risks contribute negatively to the risk premia and term spread on real bonds, while expected durables risks lead to a positive risk premium and positive slope of the real yield curve. Over the short-maturities, the nondurable consumption risks dominate, and the real term structure is downward sloping. Over the long run, the persistent durable channel takes over and makes the real yield curve upward sloping. As shown in the Table, all model restrictions to a single-good non-durable economy and/or CRRA preferences lead to a downward-sloping term structure of real interest rates.

\(^{11}\)Zeroing out the feedback effect of expected inflation to expected nondurables has an effect of increasing the persistence of expected durables and their sensitivity to expected inflation risks, which can account for a 2 basis points increase in the nominal slope.
Inflation neutrality impacts the overall level of the yields, but the term structure remains U-shaped.

4.5 Implications for Equity Prices

We calibrate the dividend growth rate in (25) and derive model implications for durable and nondurable equities and the market portfolio. We set the dividend leverage parameters to target a wide range of empirical data features for the sector portfolios. Specifically, we set the loading of durable dividend growth rate to 4.5 on expected durables, and that of nondurable dividend growth on expected nondurables to 8.5. For simplicity, we take market portfolio in the model as the weighted average of the durable and nondurable equity with a weight of $\chi = 15\%$ to the durables. We consider nominal stock returns in the model by adding the inflation rate to the corresponding real returns.

Table 7 shows the equilibrium model implications for equity returns alongside with the corresponding statistics in the data. As we discussed in Section 3, in our model durable equity dividends represent a levered claim to the durable aggregate consumption, and thus are more sensitive to movements in expected durables and expected inflation than nondurable and market dividends. This makes durable equities quite risky, which leads to a higher unconditional equity premium, higher volatility of returns and a lower level of the price-dividend ratio for durable good firms relative to the nondurable and the market. Indeed, in our calibration, durable equity premium is 6.9% relative to 4.6% for the nondurables and 5.1% for the average market, which compares well to the estimates in the data of 7.1%, 5.6% and 6.0%, respectively. Further, the model-implied standard deviation of excess returns in a durable sector is 23.1% which is larger than the volatility of nondurable equity returns of 13.8% and of the market of 16.6%. This is consistent with the empirical evidence in the data, which shows that the volatility of durable equity returns is 21.1%, the volatility of nondurable returns is 14.7% and the volatility of the market return is 16.6%. Finally, in the data, the price-dividend ratio of durable portfolios is lower than the price-dividend ratio of nondurables, and the model can match the estimates in the data very well. Indeed, the log price-dividend ratios for the durables, non-durables

\[ \text{12In the data, the durable and nondurable portfolios do not comprise the total market as we do not consider investment sector and some industries are left unclassified.} \]
and the market are 3.08, 3.32 and 3.28 in the data, compared to 3.01, 3.35 and 3.21 in the model. Note that in our model calibration, durable equities are riskier than non-durables even though the dividend leverage parameter for durables is set at a lower value than for nondurables. If the two dividend leverage parameters are the same, the difference between durable and nondurable returns becomes even more pronounced.

In addition to the model implications for the levels and volatilities of equity prices, we further consider additional model predictions for the covariation of stock returns with expected inflation and bond returns. First, as discussed in Section 3.5, in our model excess stock returns have a negative correlation with expected inflation, which is more pronounced for durable portfolios that are more exposed to inflation risk. These predictions of the model are qualitatively and quantitatively supported by the data. As shown in the Table 7 in the data the correlation of nominal excess returns with changes in expected inflation, \( \text{Corr}(r_{i,t+1} - y_{t+1}, x_{t+1} - x_t) \), is -0.43 for the durable equities, relative to -0.32 for nondurables and -0.23 for the average market. In the model, the correlation of excess stock returns with changes in expected inflation is -0.27 for the durables which is larger, in absolute value, than -0.21 for the nondurable returns and of -0.26 for the market. Further, our model implies that excess bond returns and excess equity returns should co-move positively, and the degree of the co-movement is larger for durable portfolio which is more sensitive to expected durable growth and expected inflation risks. Table 7 shows that these model implications are supported by the data. Unconditionally, the correlation of excess nominal stock return in durable portfolio with a two-year excess nominal bond returns is 0.53 in the data, relative to 0.39 for nondurables and 0.32 for the market. The correlation of stock and bond returns is larger for durables relative to nondurables for the whole sample, and also in the various subsamples, as can be seen based on a 10-year rolling window plot in Figure 6. In the model, the unconditional correlations are equal to 0.57 for durables, 0.16 for non-durables and 0.33 for the market, which are close to the estimates data.

Our evidence for an average negative correlation of stock returns with changes in expected inflation and a positive correlation with bond returns is consistent with the findings in the literature. Typically, most of the studies focus on the behaviour of the aggregate stock market; see, e.g. Fama and Schwert (1977) and Shiller and Beltratti (1993) for the U.S. evidence and Bekaert and Wang (2010) for the international evidence. Our findings are further consistent with Boudoukh et al. (1994), who consider
cross-sectional differences in industry exposures to expected inflation risk and document that in the data, highly cyclical industries, such as manufacturers of durable goods, tend to have more negative expected inflation betas than less cyclical firms. Finally, in our model the second variances of the underlying shocks are constant, so that the correlations of stock returns with inflation and bond returns do not fluctuate over time. A recent literature suggests that the conditional correlations vary over time and change sign in the data, and attributes these variations to the fluctuations in time-varying covariance between inflation and real economy (Campbell et al., 2012), fluctuations in the volatility and risk premia (Hasseltoft, 2009), learning and non-linearities in the dynamics of real growth and inflation (David and Veronesi, 2012) or liquidity factors (Bekaert et al., 2010). While for simplicity we do not consider these economic channels in our paper, it is interesting to note that the relative difference in correlations between durables and nondurables equities seems to be stable over time, as shown in Figure 6, so that the gap between the conditional correlations is of the same sign as in the model.

The key model ingredients which allow us to account for the equity market evidence in the data are the two-good structure of the economy, recursive utility and the non-neutrality of inflation on future real growth operating through the durable growth channel. As shown in Table 7 when the economy is restricted to a single consumption good, the risk premia on durable portfolio drops below the premia for the durables, and most of the correlations of equity returns with inflation and bond returns are closer to zero. We have checked that increasing risk aversion in a one-good economy to match the nominal term structure does not improve the fit to the equities: recalibrating the dividend leverage parameters to target the risk premia on the portfolios brings the model-implied correlations of stock with inflation and bond returns even closer to zero. With power utility, the model-implied unconditional values for the level and volatility of returns are significantly below the estimates in the data. Further, in expected utility the correlations between stock and expected inflation are now positive, which is counterfactual. Finally, under inflation neutrality for durable consumption, equity risk premia go down and durables become less risky relative to nondurables. Durable equity returns now correlate positively with expected inflation, and negatively with bonds. Under nondurable inflation neutrality, nondurable equity returns are virtually uncorrelated with expected inflation, and are negatively correlated with returns on bonds. This underscores the role of recursive
utility, two-good structure, and inflation non-neutrality to explain the key features of the equity markets.

5 Additional Model Implications

5.1 Long-term Yields

We consider the equilibrium implications for the long-term yields which are informative about the long-term properties of our economic model. In our benchmark model, the nominal term structure is upward sloping and flattens out at long maturities. The implied nominal yield at thirty-year maturity is 7.90\%, and it is 8.18\% at a hundred-year maturity. Similarly, the real yields, which increase with maturity after three years, reach 1.99\% at thirty years, and are equal to 2.03\% at hundred years.

The slope of the bond yield term structure and the risk premia on bonds are directly related to the properties of the stochastic discount factor. Following Bansal and Lehman (1997), Alvarez and Jermann (2005) and Hansen and Scheinkman (2009), we consider the decomposition of the pricing kernel into its transitory martingale and a dominant component:

\[
M_{t+1} = \frac{M_{t+1}^P M_{t+1}^T}{M_t^P M_t^T}.
\]  

(32)

The martingale component satisfies \( E_t M_{t+1}^P = M_t^P \), while the dominant pricing component of the pricing kernel is defined as:

\[
M_t^T = \lim_{n \to \infty} \frac{P_{t+n}}{P_{t,n}},
\]

where \( P_{t,n} \) is a price of an \( n \)-maturity bond, and \( l \) is a certain constant for a limit to be well-defined.

As discussed in Alvarez and Jermann (2005), the ratio of the conditional variance of the martingale component of the stochastic discount factor to its total conditional variance is linked to the relative amount of the total bond risk premium in the economy; in particular, this ratio is given by 1 minus the ratio of the risk premium on infinite-horizon bond to the maximum risk premium in the economy. Empirically,
the authors argue that this ratio should be close to one, as in the data long-horizon bond premia are low relative to equities and other assets. Koijen et al. (2010) further examine this ratio in the context of a single-good model specification and conclude that it can impose a tight restriction on asset-pricing models.

In our benchmark model, the ratio of the conditional variance of the transitory component to the total variance of the nominal stochastic discount factor is around 0.78, implying that the infinite horizon nominal bond risk premium is about 22% of the maximum nominal risk premium in this economy. The model-implied ratio for real discount factor is around 0.99, implying that the infinite horizon real bond risk premium is about 1% of the maximum real risk premium. These variance ratios are quite close to one, consistent with arguments in Alvarez and Jermann (2005) and Koijen et al. (2010).

5.2 Implications for CPI

In our benchmark model, we choose the nondurable consumption as a numeraire and use the change in its price index, that is, the inflation rate for nondurable goods, to compute the equilibrium prices for nominal assets. An alternative is to define a numeraire to be the aggregate consumption basket of nondurable and durable goods under the agent’s intra-temporal preferences in (3), and use the implied price index associated with the basket. However, the aggregate consumption and Consumer Price Index inflation series in the data which aggregate quantities and prices of both nondurable and durable goods are based on the weights according to the NIPA conventions, which, in principle, can be very different from the weights in the economic model. Hence, as in Piazzesi et al. (2007), we choose to use dis-aggregated series for nondurable and durable consumption and nondurable inflation to specify and estimate the model.

As a robustness check, we consider our model implications for the aggregate price index, and compare its dynamics to the CPI inflation in the data. Following the literature, the appropriate nominal price of the basket of goods is given by the ideal price index associated with agent’s preferences in (3), and is equal to:

\[
\Pi_t^{basket} = \left( (1 - \alpha)\Pi_t^{1-\epsilon} + \alpha (\Pi_t P_t^{d})^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}},
\]

(33)
where $P^d_t$ is the real purchase price of durables in terms of nondurables. We solve for the inflation rate for the ideal price index in the model, and find that it moves very closely with the CPI inflation in the data: the correlation between the two is 85%, and the means and standard deviations of the two are quite similar.

6 Conclusion

In the data, durable goods consumption growth is persistent, and the long-term growth in durable consumption and the cash-flows of durable goods producing firms are more sensitive to inflation relative to nondurables. This suggests that inflation has a non-neutral and adverse effect for future real growth, and more so for durable goods rather than non-durable goods. Motivated by these findings, we set up a two good nominal economy which features recursive utility over consumption of durable and nondurable goods, persistence fluctuations in expected growth rates and inflation non-neutrality for future real growth.

Our model can successfully, and effectively out-of-sample, account for the key features of macro data, nominal bond yields and equity prices in durable and nondurable sectors, such as an upward-sloping nominal yield curve, and higher risk premia, volatility and correlations of durable equity returns with expected inflation and bond returns, relative to nondurable equities. The two-good structure, recursive utility and a non-neutral effect of inflation on future growth play the key role to explain these data features.
Appendix

A Model Solution

The log-linearization parameter for the consumption asset $\kappa_1$ satisfies the following recursive equation:

$$
\log \kappa_1 = \log \beta + \left( 1 - \frac{1}{\psi} \right) \left( (1 - \chi) i_c + \chi (i_a + i_s) \right)' \mu \\
+ \frac{1}{2} \theta \left( 1 - \frac{1}{\psi} \right)^2 \left( (1 - \chi) i_c + \chi (i_a + i_s) \right)' \Sigma_g \Sigma_g' \left( (1 - \chi) i_c + \chi (i_a + i_s) \right) \\
+ \frac{1}{2} \theta \kappa_1 \Sigma_x \Sigma_x' A_x.
$$  (A.1)

The discount factor parameters are given by

$$
m_0 = \theta \log \delta + (1 - \theta) \log \kappa_1 - \lambda_g \mu.
$$  (A.2)

The nominal discount factor parameters satisfy

$$
m^g_0 = m_0 - i_\pi \mu, \quad m^g_x = m_x - F_i \pi, \quad \lambda^g = \lambda_g + i_\pi,
$$  (A.3)

where $i_\pi = [0 \ 1]'$.

The solution for real bond price loadings are given by,

$$
B_{0,n} = B_{0,n-1} - m_0 - \frac{1}{2} \lambda_y \Sigma_g \Sigma_g' \lambda_y - \frac{1}{2} \left( \lambda_x + B_{x,n-1} \right)' \Sigma_x \Sigma_x' \left( \lambda_x + B_{x,n-1} \right),
$$  (A.4)

$$
B_{x,n} = \Pi_i B_{x,n-1} - m_x,
$$

and similar for nominal bonds using the parameters of the nominal discount factor in Equation (A.3).

B MCMC Estimation

In order to perform inference for the parameters in our model we estimate the posterior distributions of the model parameters using Bayesian MCMC.

Bayes’ theorem says that the posterior $\pi(\Theta \mid Y)$ is proportional to the likelihood multiplied by the prior, $\pi(\Theta \mid Y) \propto \mathcal{L}(Y ; \Theta)p(\Theta)$. The likelihood function, $\mathcal{L}$, can be computed through Kalman filtering as described in the following.
Let \( \eta^*_t = \Sigma g \eta_t \) is defined as the exogenous random shock to the macro-variables \( g_t \) in equation (11),

\[
\eta^*_t = y_t - \mu_y - x_t.
\]

Let \( Y_{t}^{\text{data}} \) denote a vector of observed zero coupon yields of different maturities. Define

\[
u_t = Y_{t}^{\text{data}} - Y_{t}^{\text{model}}
\]

where \( Y_{t}^{\text{model}} \) is our model implied counterpart, so that an \( n \) maturity zero is \( Y_{t}^{\text{model}} = -p_{t,n}/n \) where \( p_{t,n} \) is the log bond price. We assume

\[
u_t \sim N(0, \Sigma_u)
\]

where \( \Sigma_u \) is diagonal so that we force the pricing errors to be uncorrelated across bonds.

A vector of time \( t \) errors are now given by

\[
\epsilon_t = \begin{bmatrix} \eta_t \\ u_t \end{bmatrix}
\]

where \( \epsilon_t \sim N(0, \Sigma) \), and

\[
\Sigma = \begin{bmatrix} \Sigma_g & 0 \\ 0 & \Sigma_u \end{bmatrix}.
\]

The dynamics of \( Y_t = (g_t, Y_{t}^{\text{data}}) \) forms a linear state-space model,

\[
Y_t = \mu + F x_t + \epsilon_t
\]

where

\[
F = \begin{bmatrix} I_3 & 0 \\ 0 & -B_{2,n}^f/n \end{bmatrix}
\]

and \( \mu = (\mu_g, -B_{0,n}/n) \) and where \( B_{0,n} \) and \( B_{2,n}^f \) are given by the equations (A.4). We can now apply standard Kalman filtering to compute the likelihood function. Specifically, we perform Bayesian posterior simulations using MCMC sampling under an un-informative prior. Let \( V \) denote an estimate of the covariance of the posterior distribution. Draw \( \Theta_p \sim N(\Theta_J, V) \). Set \( \Theta = \Theta_p^\nu \) with probability \( \alpha = \min(1, \pi(\Theta_p^\nu)/\pi(\Theta)) \). In practice, we update fewer than all \( n \) parameters in one iteration of the sampler. This avoids the curse of dimensionality associated with sampling in high dimensional parameter spaces.

For the estimation of macroeconomic dynamics without the yield data, we omit \( Y_{t}^{\text{data}} \) in the specification of \( Y_t \).
References


Branger, Nicole, Ioana Dumitrescu, Vesela Ivanova, and Christian Schlag, 2011, Two trees the ez way, working paper.


Guo, Na, and Peter Smith, 2010, Durable consumption, long-run risk and the equity premium, working paper.


Ready, Robert, 2010, Oil prices and long-run risk, working paper.


Tables and Figures

Table 1: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Non-Dur Consumption</th>
<th>Non-Dur Inflation</th>
<th>Durable Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.21</td>
<td>4.16</td>
<td>4.33</td>
</tr>
<tr>
<td>Stdev.</td>
<td>0.90</td>
<td>1.25</td>
<td>0.94</td>
</tr>
<tr>
<td>Autocorr</td>
<td>0.33</td>
<td>0.84</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Corr. with Cons.:

<table>
<thead>
<tr>
<th></th>
<th>Non-Dur</th>
<th>Dur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Dur</td>
<td>1.00</td>
<td>-0.27</td>
</tr>
<tr>
<td>Dur</td>
<td>0.39</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Mean, volatility, autocorrelation and cross-correlations of real non-durable consumption growth, non-durable inflation and real durable consumption growth. Mean and volatility are annualized, in percent. Quarterly observations from 1963Q1 to 2006Q4.
Table 2: Consumption Growth Projections

<table>
<thead>
<tr>
<th></th>
<th>1 yr</th>
<th>2 yr</th>
<th>3 yr</th>
<th>4 yr</th>
<th>5 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-durable Consumption Growth:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Inflation:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.863</td>
<td>−0.623</td>
<td>−0.411</td>
<td>−0.252</td>
<td>−0.161</td>
</tr>
<tr>
<td></td>
<td>(0.144)</td>
<td>(0.113)</td>
<td>(0.095)</td>
<td>(0.081)</td>
<td>(0.072)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.192</td>
<td>0.167</td>
<td>0.110</td>
<td>0.060</td>
<td>0.032</td>
</tr>
<tr>
<td><em>Interest Rate:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.194</td>
<td>−0.135</td>
<td>−0.067</td>
<td>−0.02</td>
<td>−0.009</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.029)</td>
<td>(0.025)</td>
<td>(0.021)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.154</td>
<td>0.125</td>
<td>0.046</td>
<td>0.006</td>
<td>0.002</td>
</tr>
<tr>
<td><em>Interest rate and Inflation:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope (yld)</td>
<td>−0.123</td>
<td>−0.098</td>
<td>−0.030</td>
<td>0.012</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>(0.051)</td>
<td>(0.040)</td>
<td>(0.034)</td>
<td>(0.029)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Slope (infl)</td>
<td>−0.121</td>
<td>−0.062</td>
<td>−0.063</td>
<td>−0.052</td>
<td>−0.043</td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.047)</td>
<td>(0.040)</td>
<td>(0.034)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.176</td>
<td>0.135</td>
<td>0.061</td>
<td>0.021</td>
<td>0.015</td>
</tr>
<tr>
<td><strong>Durable Consumption Growth:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Inflation:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.936</td>
<td>−1.170</td>
<td>−1.176</td>
<td>−1.067</td>
<td>−0.929</td>
</tr>
<tr>
<td></td>
<td>(0.203)</td>
<td>(0.177)</td>
<td>(0.159)</td>
<td>(0.147)</td>
<td>(0.137)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.123</td>
<td>0.223</td>
<td>0.264</td>
<td>0.258</td>
<td>0.233</td>
</tr>
<tr>
<td><em>Interest Rate:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.266</td>
<td>−0.284</td>
<td>−0.241</td>
<td>−0.176</td>
<td>−0.126</td>
</tr>
<tr>
<td></td>
<td>(0.050)</td>
<td>(0.045)</td>
<td>(0.042)</td>
<td>(0.040)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.158</td>
<td>0.209</td>
<td>0.175</td>
<td>0.112</td>
<td>0.094</td>
</tr>
<tr>
<td><em>Interest Rate and Inflation:</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope (yld)</td>
<td>−0.133</td>
<td>−0.136</td>
<td>−0.074</td>
<td>0.004</td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.060)</td>
<td>(0.049)</td>
<td>(0.053)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Slope (infl)</td>
<td>−0.225</td>
<td>−0.249</td>
<td>−0.281</td>
<td>−0.304</td>
<td>−0.314</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.071)</td>
<td>(0.066)</td>
<td>(0.062)</td>
<td>(0.057)</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.199</td>
<td>0.268</td>
<td>0.264</td>
<td>0.234</td>
<td>0.224</td>
</tr>
</tbody>
</table>

Slope coefficients and $R^2$s in projections of average future cumulative real consumption growth rates on inflation rate, 3-month nominal interest rate and jointly on inflation and interest rate. Top panel reports projections for non-durable consumption growth rate, while bottom panel reports the results for durable consumption growth. Quarterly data from 1963Q1 to 2006Q4. Standard errors are Newey-West adjusted.
Table 3: Dividend Growth Projections

<table>
<thead>
<tr>
<th></th>
<th>1 yr</th>
<th>2 yr</th>
<th>3 yr</th>
<th>4 yr</th>
<th>5 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-durable Portfolio:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.33</td>
<td>−0.24</td>
<td>−0.08</td>
<td>−0.01</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>(0.78)</td>
<td>(0.58)</td>
<td>(0.46)</td>
<td>(0.35)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Durable Portfolio:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−2.56</td>
<td>−1.82</td>
<td>−1.23</td>
<td>−0.83</td>
<td>−0.49</td>
</tr>
<tr>
<td></td>
<td>(0.99)</td>
<td>(0.79)</td>
<td>(0.74)</td>
<td>(0.61)</td>
<td>(0.56)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.14</td>
<td>0.12</td>
<td>0.07</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Market Portfolio:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>−0.96</td>
<td>−0.87</td>
<td>−0.67</td>
<td>−0.43</td>
<td>−0.18</td>
</tr>
<tr>
<td></td>
<td>(0.67)</td>
<td>(0.55)</td>
<td>(0.45)</td>
<td>(0.35)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
<td>0.04</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Slope coefficients and $R^2$s in projections of average cumulative future real dividend growth rates on inflation for equity portfolios in a durable sector, non-durable sector and the aggregate market. Annual data from 1963Q1 to 2006Q4. Standard errors are Newey-West adjusted.
### Table 4: Benchmark Parameter Estimates

**Macro Model Parameters:**

<table>
<thead>
<tr>
<th></th>
<th>$\Delta c_t$</th>
<th>$\Delta \pi_t$</th>
<th>$\Delta s_t$</th>
<th>$\Delta c_t$</th>
<th>$\Delta \pi_t$</th>
<th>$\Delta s_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Pi$</td>
<td>0.388 (0.002)</td>
<td>-0.060 (0.041)</td>
<td>-0.027 (0.029)</td>
<td>4.056 (0.020)</td>
<td>1.410 (0.873)</td>
<td></td>
</tr>
<tr>
<td>$\Sigma_x \times 1000$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{diag}(\Sigma_g) \times 1000$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\Delta c_t$</th>
<th>$\Delta \pi_t$</th>
<th>$\Delta s_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \pi_t$</td>
<td>0.162 (0.069)</td>
<td>0.954 (0.004)</td>
<td>-0.008 (0.043)</td>
</tr>
<tr>
<td>$\Delta s_t$</td>
<td>0.009 (0.042)</td>
<td>-0.108 (0.014)</td>
<td>0.876 (0.018)</td>
</tr>
</tbody>
</table>

**Preference Parameters:**

<table>
<thead>
<tr>
<th></th>
<th>$\gamma$</th>
<th>$\psi$</th>
<th>$\delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.49 (37.3)</td>
<td>2.22 (0.49)</td>
<td>0.996</td>
</tr>
</tbody>
</table>

Parameter estimates of the benchmark model specification. Macroeconomic parameters $\Pi, \Sigma_x$ and $\Sigma_g$ are estimated by Kalman-filter MLE using the macro data on non-durable consumption growth, non-durable inflation and durable goods growth. Preference parameters are estimated based on the Non-linear Least Square fit to 1 and 5 year nominal yields. Quarterly data from 1963Q1 to 2006Q4.
Table 5: Nominal Bond Yields: Data and Models

<table>
<thead>
<tr>
<th></th>
<th>EZ Data</th>
<th>CRRA 2Good</th>
<th>CRRA NonDur</th>
<th>CRRA Dur</th>
<th>CRRA NonDur</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield Level:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1y</td>
<td>6.25</td>
<td>6.25</td>
<td>6.64</td>
<td>59.85</td>
<td>50.88</td>
</tr>
<tr>
<td>3y</td>
<td>6.62</td>
<td>6.60</td>
<td>6.70</td>
<td>58.48</td>
<td>49.78</td>
</tr>
<tr>
<td>5y</td>
<td>6.83</td>
<td>6.83</td>
<td>6.76</td>
<td>57.92</td>
<td>49.60</td>
</tr>
<tr>
<td><strong>Yield Volatility:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1y</td>
<td>2.77</td>
<td>1.95</td>
<td>1.84</td>
<td>8.99</td>
<td>6.11</td>
</tr>
<tr>
<td>3y</td>
<td>2.63</td>
<td>1.65</td>
<td>1.50</td>
<td>6.08</td>
<td>2.21</td>
</tr>
<tr>
<td>5y</td>
<td>2.53</td>
<td>1.41</td>
<td>1.26</td>
<td>5.21</td>
<td>1.36</td>
</tr>
<tr>
<td><strong>MSE:</strong></td>
<td>0</td>
<td>2.03</td>
<td>2.12</td>
<td>54.60</td>
<td>45.18</td>
</tr>
<tr>
<td>1y Yield</td>
<td>0</td>
<td>0.82</td>
<td>0.94</td>
<td>5.91</td>
<td>5.38</td>
</tr>
<tr>
<td>5y Spread</td>
<td>0</td>
<td>-0.61</td>
<td>0.00</td>
<td>16.20</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Yield Loadings:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. Nd</td>
<td>2.65</td>
<td>2.41</td>
<td>1.80</td>
<td>69.78</td>
<td>85.98</td>
</tr>
<tr>
<td></td>
<td>(0.91)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. Infl.</td>
<td>3.667</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>(0.311)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. Dur.</td>
<td>-1.71</td>
<td>-0.61</td>
<td>0.00</td>
<td>16.20</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.43)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Levels, volatilities, the Minimum Squared Error (MSE) of nominal yields in the data and across economic models. Yield loadings show the slope coefficients in the regression of a one-quarter nominal yield on the expected growth and inflation states, in the data and across the models. EZ denotes a recursive utility model, CRRA stands for the model specification under expected utility where the inter-temporal elasticity of substitution is set to the reciprocal of the risk aversion, and Infl. Neutrality indicates that the interaction of expected inflation from durable or nondurable growth is zeroed out. 2Good indicates that the model is based on durable and nondurable goods.
### Table 6: Model-Implied Real Yields

<table>
<thead>
<tr>
<th>Yield Level</th>
<th>EZ 2Good</th>
<th>EZ NonDur</th>
<th>CRRA 2Good</th>
<th>CRRA NonDur</th>
<th>Infl. Neutrality Dur</th>
<th>Infl. Neutrality NonDur</th>
</tr>
</thead>
<tbody>
<tr>
<td>1y</td>
<td>1.86</td>
<td>2.35</td>
<td>55.62</td>
<td>46.64</td>
<td>1.99</td>
<td>1.88</td>
</tr>
<tr>
<td>3y</td>
<td>1.82</td>
<td>2.31</td>
<td>54.19</td>
<td>45.49</td>
<td>1.96</td>
<td>1.87</td>
</tr>
<tr>
<td>5y</td>
<td>1.84</td>
<td>2.30</td>
<td>53.51</td>
<td>45.26</td>
<td>1.96</td>
<td>1.91</td>
</tr>
<tr>
<td>10y</td>
<td>1.90</td>
<td>2.29</td>
<td>52.20</td>
<td>45.05</td>
<td>1.96</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Model-implied term structure of interest rates on real bonds which deliver one unit of non-durable consumption. EZ denotes a recursive utility model, CRRA stands for the model specification under expected utility where the inter-temporal elasticity of substitution is set to the reciprocal of the risk aversion, and Infl.Neutrality indicates that the interaction of expected inflation from durable or nondurable growth is zeroed out. 2Good indicates that the model is based on durable and nondurable goods.
Table 7: Equity Returns: Data and Model

<table>
<thead>
<tr>
<th></th>
<th>EZ Data</th>
<th>CRRA 2Good</th>
<th>CRRA NonDur</th>
<th>Infl. Neutrality Dur</th>
<th>Infl. Neutrality NonDur</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equity Premium:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Dur</td>
<td>5.62</td>
<td>4.58</td>
<td>3.24</td>
<td>0.18</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(2.25)</td>
<td>(3.22)</td>
<td>(2.54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dur</td>
<td>7.11</td>
<td>6.86</td>
<td>3.62</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(3.22)</td>
<td>(3.22)</td>
<td>(3.22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mkt</td>
<td>5.97</td>
<td>5.05</td>
<td>3.24</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(2.54)</td>
<td>(2.54)</td>
<td>(2.54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Equity Volatility:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Dur</td>
<td>14.73</td>
<td>13.83</td>
<td>13.65</td>
<td>16.05</td>
<td>16.58</td>
</tr>
<tr>
<td></td>
<td>(1.35)</td>
<td>(1.94)</td>
<td>(1.41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dur</td>
<td>21.11</td>
<td>23.08</td>
<td>25.33</td>
<td>24.10</td>
<td>25.01</td>
</tr>
<tr>
<td></td>
<td>(1.94)</td>
<td>(1.94)</td>
<td>(1.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td>(1.41)</td>
<td>(1.41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Log PD ratio:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Dur</td>
<td>3.32</td>
<td>3.35</td>
<td>3.63</td>
<td>0.50</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dur</td>
<td>3.08</td>
<td>3.01</td>
<td>4.29</td>
<td>0.52</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mkt</td>
<td>3.28</td>
<td>3.21</td>
<td>3.6</td>
<td>0.50</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Corr. with Exp. Infl.:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Dur</td>
<td>-0.32</td>
<td>-0.21</td>
<td>-0.19</td>
<td>0.05</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.14)</td>
<td>(0.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dur</td>
<td>-0.43</td>
<td>-0.27</td>
<td>-0.31</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mkt</td>
<td>-0.23</td>
<td>-0.26</td>
<td>-0.19</td>
<td>0.07</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.14)</td>
<td>(0.14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Corr. with Bonds:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Dur</td>
<td>0.39</td>
<td>0.16</td>
<td>0.12</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.12)</td>
<td>(0.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dur</td>
<td>0.53</td>
<td>0.57</td>
<td>0.59</td>
<td>0.40</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mkt</td>
<td>0.32</td>
<td>0.33</td>
<td>0.12</td>
<td>0.43</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
<td>(0.14)</td>
<td>(0.14)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equity prices of durable and nondurable portfolios and the market in the data and in the model. EZ denotes a recursive utility model, CRRA stands for the model specification under expected utility where the inter-temporal elasticity of substitution is set to the reciprocal of the risk aversion, and Infl.Neutrality indicates that the interaction of expected inflation from durable or nondurable growth is zeroed out. 2Good indicates that the model is based on durable and nondurable goods.
Autocorrelation functions of non-durable and durable consumption growth and non-durable inflation rate based on the estimates in the data and implied by the macroeconomic model. Quarterly observations from 1963Q1 to 2006Q4.
Impulse response functions for shocks to expected non-durable consumption, expected durable consumption and expected non-durable inflation, based on the estimated macroeconomic model. Grey regions correspond to 90% confidence interval.
Figure 3: Realized and Filtered Macroeconomic Variables

Realized and filtered non-durable consumption growth rate, non-durable inflation rate and durable goods growth rates.
Time series of one-year nominal yield in the data (dashed line) and in the model (solid line).
Figure 5: Nominal Yield Spread: Data and Model

Time series of five minus one year nominal spread in the data (dashed line) and in the model (solid line).
Figure 6: Correlations Between Excess Stock Return and Excess Bond Return

The difference of the correlation between durable portfolio excess stock returns and nominal bond (2-year) excess return and the correlation between the nondurable portfolio excess stock return and nominal bond (2-year) excess return. The correlations are computed in a 10-year rolling window.