Nominal Rigidities and Asset Pricing

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Abstract

This paper examines the asset pricing implications of nominal rigidities. Firms that adjust their product prices infrequently earn a return premium of more than 4% per year. Merging unique product-price data at the firm level with stock returns, I document that the premium for sticky-price firms is a robust feature of the data and varies substantially over the business cycle. The premium is not driven by other firm and industry characteristics. Differential exposure to systematic risk fully explains the premium for sticky-price firms. A multi-sector New Keynesian asset-pricing model with sectors differing in their frequency of price adjustment is consistent with these novel facts.

JEL classification: E12, E44, E52, G12

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I   Introduction

The cover price of the Wall Street Journal was constant during the Roaring Twenties, the Great Depression, and the Second World War despite large swings in economic conditions.[1] Although the example of the Wall Street Journal is certainly extreme, rigid product prices are pervasive in micro data.[2] Nominal rigidities play a central role in macroeconomics in explaining business-cycle dynamics of aggregate real quantities and are key ingredients of dynamic models at policy institutions.[3] Most importantly, price rigidities are the cornerstone of many economic models that rationalize the effects of purely *nominal* shocks on the *real* side of the economy.[4]

In this paper, I study whether infrequent product-price changes at the firm level are a source of macroeconomic risk that is priced in the cross section of stock returns. I find that sticky-price firms are risky and command a return premium compared to firms with flexible prices. The premium is 4% per year and in the order of magnitude of the size and value premia, which are the two most studied return premia in finance. Differential exposure to systematic risk fully explains the premium for sticky-price firms. The premium varies substantially over the business cycle and is high in recessions and stock market downturns. A multi-sector New Keynesian asset-pricing model in which sectors differ in the degree of price stickiness is consistent with these novel stylized facts.

I measure price stickiness as the average frequency of product-price adjustment at the firm level. I construct this metric using the confidential microdata underlying the Producer Price Index (PPI) at the Bureau of Labor Statistics (BLS), and merge it with financial data from the Center for Research in Security Prices (CRSP) and Compustat. I show that portfolios of firms sorted on the frequency of price adjustment generate a return differential of 4.4% per year between sticky- and flexible-price firms. Returns monotonically decrease in the degree of price flexibility.

The return premium for sticky-price firms is a robust feature of the data. Standard cross-sectional return predictors at the firm and industry level cannot explain the premium in firm-level panel regressions. In a non-parametric analysis using conditional double

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[1]See Knotek II (2008).

[2]Prices at the good level for the whole U.S. economy remain unchanged for roughly six months on average. See Bils and Klenow (2004) and Nakamura and Steinsson (2008).

[3]See Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), and Galí (2009).

[4]See Kehoe and Midrigan (2012).

sorts, I show the premium is also not driven by non-linear relationships between firm characteristics and returns and is similar in magnitude to the value premium. Unobserved industry-level heterogeneity does also not drive the premium for sticky-price firms.

I then investigate the properties of the return premium. First, I test whether differential exposure to systematic risk can explain the difference in returns between sticky- and flexible-price firms. The Capital Asset Pricing Model (CAPM) cannot explain the level of portfolio returns sorted on the frequency of price adjustment, but it can fully explain the cross-sectional dispersion: sticky-price firms have on average a sensitivity to the market excess return (β) of 1.29. βs decrease monotonically in price flexibility, resulting in a difference in exposure to market risk of 0.37 between the sticky- and flexible-price firms. Sticky-price firms are more exposed to market risk and therefore earn a return premium.

Second, I investigate why the CAPM is successful despite being typically rejected in the data. Variation in the aggregate stock market can occur either due to news about future discount rates or news about future cash flows. Differential exposure to the two sources of fundamental risk across portfolios can explain why the overall β might not be a sufficient statistic in case of different market prices of risk. I find that sticky-price firms have higher exposure to both sources of fundamental risk and are unambiguously riskier than firms with flexible prices.

Third, I study the sensitivity of portfolio returns to monetary policy shocks. Monetary policy shocks are important for aggregate risk premia. 60%-80% of the realized equity premium is earned around scheduled macroeconomics news announcements. I find that sticky-price firms are twice as responsive to monetary policy shocks compared to flexible price firms. The differential reaction across portfolios is broadly in line with the CAPM. The CAPM has high explanatory power for the cross section of stocks sorted on the frequency of price adjustment, both unconditionally and conditional on the realization of monetary policy shocks. These results underline the role of the frequency of price adjustment as a determinant of the cross section of stock returns and the power of monetary policy to affect the real side of the economy.

Last, I examine the time-series characteristics of the premium for sticky-price firms. The premium varies systematically over the business cycle and is high in recessions and times of low stock market returns. The Lettau and Ludvigson (2001) proxy for the

consumption-wealth ratio (cay) can explain up to 60% of the business-cycle variation in long-horizon regressions. The higher cost of capital for sticky-prices firms in times of recessions and low aggregate stock returns has potentially interesting implications for firms' investment decisions and could contribute to the importance of price ridigties for aggregate fluctuations.

I develop a multi-sector New Keynesian production-based asset-pricing model to organize the novel stylized facts in a coherent setting and to test whether the premium for sticky-price firms can be rationalized within such a framework. Households derive utility from a composite consumption good and leisure. The production side is organized in different sectors. Firms are monopolistically competitive and set prices as a markup over a weighted average of future marginal costs. The only heterogeneity across sectors is a different degree of price stickiness. The basic structure of my model is similar to Carvalho (2006). Mine differs in several ways. I add external habit formation in consumption and wage stickiness to get a reasonable equity premium. I also allow for different elasticities of substitution in consumption varieties within and across sectors, because they play a distinct role for cross-sectional return premia.

I calibrate the model using standard parameters to the empirical distribution of price stickiness from Nakamura and Steinsson (2008). The model is successful in replicating the novel stylized facts, a large premium for sticky-price firms that varies over the business cycle, and an equity premium in line with historical estimates.

The paper makes three main contributions. First, I contribute to the macroeconomics literature by documenting that differences in the frequency of price adjustment are associated with differences in expected returns. Price stickiness therefore has real costs for firms; it increases the cost of capital, and firms might forgo profitable investment projects. Second, I contribute to the industrial organization literature by aggregating good-based measures of price stickiness to the establishment and firm level. The different levels of aggregation allow the test of models of price setting at the firm level using micro data from official statistics. Third, I contribute to the finance literature by documenting that the frequency of price adjustment is a strong determinant of exposure to systematic risk and is priced in the cross section of stock returns. A firm's exposure to systematic risk is a function of several parameters and factors. The frequency of product-price adjustment is a simple variable at the firm level that can account for a considerable part of the

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variation in firms' exposure to systematic risk. Therefore, price rigidities are important both for business-cycle dynamics in aggregate quantities and cross-sectional variation in stock returns, and further bridge macroeconomics and finance.

A. Related Literature

The paper is related to a large literature in macroeconomics documenting stylized facts about the pricing behavior of firms, and to the asset-pricing literature on production-based asset pricing, the equity premium, and the relationship between firm characteristics and cross-sectional return-premia.

A.1 Macroeconomics

Using data from retail catalogs, Kashyap (1995) shows that nominal prices are fixed for more than one year. Zbaracki, Ritson, Levy, Dutta, and Bergen (2004) document in detail for a large U.S. manufacturer the costs associated with changing prices, such as data collection, managerial costs, physical costs, or negotiation costs. The total cost of changing nominal prices is 1.22% of total revenue and 20.03% of the company's net profit margin. Bils and Klenow (2004) and Nakamura and Steinsson (2008) use the microdata underlying the Consumer Price Index (CPI) at the BLS to show that prices are fixed for roughly six months and that substantial heterogeneity is present in price stickiness across industries. Goldberg and Hellerstein (2011) confirm these findings for producer prices.[5] Gorodnichenko and Weber (2013) use the micro data underlying the PPI to test alternative theories of price stickiness in micro data. Performing high-frequency-event studies around the press releases of the Federal Open Market Committee, they provide evidence consistent with a New Keynesian interpretation of price stickiness. Gilchrist, Schoenle, Sim, and Zakrajsek (2013) investigate the price-setting behavior of firms during the Great Recession as a function of balance sheet conditions.

A.2 Finance

A recent literature in finance focuses on the potential of wage and price rigidities to explain aggregate stock market patterns in production economies. Uhlig (2007) shows that external habits and real-wage stickiness generate an equity premium. Favilukis and Lin

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[5]Other recent contributions to this literature are Golosov and Lucas Jr. (2007), Klenow and Willis (2007), Klenow and Kryvtsov (2008), Eichenbaum, Jaimovich, and Rebelo (2011), Midrigan (2011), Anderson, Jaimovich, and Simester (2014), Kehoe and Midrigan (2012), Bhattarai and Schoenle (2012), Eichenbaum, Jaimovich, Rebelo, and Smith (2013), and Vavra (2013). Klenow and Malin (2010) and Nakamura and Steinsson (2013) provide excellent reviews of the recent literature on price rigidity using micro price data.

(2013) develop a production-based asset-pricing model with sticky wages and employment-adjustment costs, whereas Li and Palomino (2014) introduce sticky prices and wages. Both papers have Epstein and Zin (1989) and Weil (1989) recursive preferences and are able to generate empirically reasonable levels of the equity risk premium in calibrations.[6] I contribute to this literature by theoretically showing the impact of heterogeneity in price stickiness on cross-sectional return premia. To the best of my knowledge, this paper is the first to test for the effects of nominal rigidities on stock returns at the firm level.

In addition, I contribute to the literature linking firm characteristics to stock returns in the cross section. Fama and French (1992) offer a concise treatment of many cross-sectional relationships in a unified setting. Berk, Green, and Naik (1999), Carlson, Fisher, and Giammarino (2004), and Gomes, Kogan, and Zhang (2003) document that these premia naturally arise from firms' optimal production and investment behavior. Bustamante and Donangelo (2014), and Donangelo (2014) relate industry concentration, product market competition, and labor mobility across industries to expected returns in the cross section. Van Binsbergen (2014) studies the impact of good-specific habit formation and finds that cross-sectional variation in the demand for goods leads to differences in expected returns across industries.[7]

I add to this literature by documenting that different pricing technologies in product markets lead to different exposure to systematic risk. A difference in average conditional βs of almost 0.40 explains the return spread between sticky- and flexible-price firms.

II Data

This section describes both my measure of the frequency of product-price adjustment at the firm level, and the financial data I use.

A. Measuring Price Stickiness

A key ingredient of my analysis is a measure of price stickiness at the firm level. I use the confidential microdata underlying the PPI at the BLS to calculate the frequency of price adjustment at the firm level. The PPI measures changes in selling prices from

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[6]Kuehn, Petrosky-Nadeau, and Zhang (2012) incorporate search and matching frictions in a production-based asset-pricing model and show that this friction endogenously generates consumption disasters.

[7]See also Gomes, Kogan, and Yogo (2009), Gârleanu, Kogan, and Panageas (2012), Kogan and Papanikolaou (2012), and Jones and Tuzel (2013), among many others.

the perspective of producers, and tracks prices of all goods-producing industries such as mining, manufacturing, gas and electricity, as well as the service sector.[8]

The BLS applies a three-stage procedure to determine the individual sample goods. In the first stage, the BLS compiles a list of all firms filing with the Unemployment Insurance system to construct the universe of all establishments in the United States. In the second and third stages, the BLS probabilistically selects sample establishments and goods based on the total value of shipments or on the number of employees. The BLS collects prices from about 25,000 establishments for approximately 100,000 individual items on a monthly basis. The BLS defines PPI prices as "net revenue accruing to a specified producing establishment from a specified kind of buyer for a specified product shipped under specified transaction terms on a specified day of the month." Prices are collected via a survey that is emailed or faxed to participating establishments. Individual establishments remain in the sample for an average of seven years until a new sample is selected to account for changes in the industry structure.

I calculate the frequency of price adjustment at the good level, SA, as the ratio of price changes to the number of sample months. For example, if an observed price path is $4 for two months and then $5 for another three months, one price change occurs during five months and the frequency is $1/5$.[9] I calculate both equally weighted frequencies, U, and frequencies weighted by values of shipments associated with items/establishments, W.

I first aggregate goods-based frequencies to the establishment level via internal identifiers of the BLS. To perform the firm-level aggregation, I check whether establishments with the same or similar names are part of the same company. In addition, I use publicly available data to search for names of subsidiaries and name changes due to, for example, mergers, acquisitions, or restructuring occurring during the sample period for all firms in the data set. Appendix $C.$ discusses in more detail how the aggregations are performed.

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[8]The BLS started sampling prices for the service sector in 2005. The PPI covers about 75% of the service sector output. My sample of micro price data ranges from 1982 to 2011. The data until 1998 are equivalent to the data used in Nakamura and Steinsson (2008).

[9]When calculating the frequency of price adjustment, I exclude price changes due to sales, using the filter of Nakamura and Steinsson (2008). Including sales does not affect my results because sales are rare in producer prices (see Nakamura and Steinsson (2008)). My baseline measure treats missing price values as interrupting price spells. The appendix contains results for alternative measures of the frequency of price adjustment; results are quantitatively and statistically similar.

Table 1 reports mean frequencies, standard deviations, and the number of firm-month observations for the frequency of price adjustment, both for the total sample and at the industry level.[10] I focus on the unweighted frequency of price adjustment, SAU, because results are similar across the two measures.[11] The overall mean monthly frequency of price adjustment is 14.86%, which implies an average duration, $-1/ln(1-SAU)$, of 6.22 months. Substantial heterogeneity is present in the frequency across sectors, ranging from as low as 8.13% for the service sector (duration of one year) to 22.75% for agriculture (duration of 3.88 months). Finally, the high standard deviations highlight large heterogeneity in measured price stickiness across firms even within industries.

Different degrees of price stickiness of similar firms operating in the same industry can arise due to differences in the costs of negotiating with customers and suppliers, in the physical costs of changing prices, or in the managerial costs such as information gathering, decision making, and communication.[12]

B.   Financial Data

I focus on firms that have been part of the S&P500 between 1994 and 2009 because of the availability of the PPI data and to keep the manual merging between the two data sets manageable.[13] The previous literature has identified a series of financial variables that have predictive power for the cross section of stock returns. I construct measures of market capitalization (Size), sensitivity to the aggregate stock market (β (Beta)), share turnover (Turnover), and the bid-ask spread (Spread) using the CRSP database. I obtain balance-sheet data from Standard and Poor's Compustat database to construct measures of the ratio of book equity to market equity (BM), leverage (Lev), cash flow (CF), price-to-cost margin (PCM), and the Herfindahl-Hirschman index of sales at the Fama & French 48 industry level at an annual frequency (HHI).[14] Appendix $D.$ contains

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[10]The coarse definition of industry is due to confidentiality reasons and partially explains the substantial variation of the measures of price stickiness within industry.

[11]I report results for the weighted frequencies of price adjustment in appendix Table A.1.

[12]These differences might arise because of differences in customer and supplier structure, heterogeneous organizational structure, or varying operational efficiencies and management philosophies (see Zbaracki et al. (2004)).

[13]I have 956 unique firms in my sample due to changes in the index composition during my sample period, out of which I was able to merge 760 with the BLS pricing data. The merged and overall sample of firms look virtually identical with respect to the studied firm characteristics (compare Table 2 to Table A.2 in the appendix).

[14]I winsorize all variables at the 2.5% level to minimize the effect of extreme observations and outliers. Results are similar if I perform my analysis on unwinsorized data (see appendix).

detailed variable definitions.

Table 2 summarizes time-series averages of annual means and standard deviations of the return predictors in Panel A as well as contemporaneous correlations in Panel B. I have on average more than 500 firms per year. My sample consists of large major U.S. companies with a mean size of more than \$3 billion and a β of slightly above 1. In Panel B, we see that firms with more flexible prices have higher book-to-market ratios and leverage, but also lower βs and price-to-cost margins. The positive correlation with leverage might indicate that price flexibility in product markets increases the debt capacity of firms via reduced default costs. The higher β for sticky-price firms suggests higher riskiness. The positive correlation with the price-to-cost margin highlights the importance of disentangling the frequency of price adjustment from other covariates. Firms with low frequencies of price adjustment might have *market power* and therefore be unresponsive to changes in costs or demand instead of facing *costs* of changing nominal prices.[15]

III   Empirical Results

A.   Portfolio Level

I sort stocks into five portfolios based on the frequency of price adjustment, SAU, to test if differences in price stickiness are associated with differences in returns. The frequency of price adjustment is by construction monotonically increasing from as low as 0.01 for portfolio 1 to 0.35 for the flexible price portfolio (see Table A.4 in the appendix for firm characteristics at the portfolio level). I measure annual returns from July of year t to June of year t+1, and I weight returns equally within each portfolio.[16]

Panel A of Table 3 reports average annual returns for various sample periods. The sorting generates a spread in returns between the sticky- and flexible-price firms of 2.7%–6.7% per year. This premium is statistically significant and economically large. Mean returns decrease monotonically in the degree of price flexibility. The return premium is larger after the Volcker disinflation, with a non-binding zero lower bound on nominal interest rates and before the start of the Great Recession. In the rest of the paper, I focus

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[15]Appendix Table A.3 and Table A.4 report further descriptive statistics for the frequency of price adjustment and its' association with firm characteristics.

[16]The frequency of price adjustment at the firm level shows little variation over time. I do not rebalance portfolios but only sort once at the beginning of the sample period to minimize concerns about measurement error in the frequency of price adjustment.

on a period from July 1982 to June 2007. The micro data I use to construct the frequency of price adjustment start in 1982. I limit the analysis to 2007 in order to circumvent the concerns associated with a binding zero lower bound on nominal interest rates and the effects of the Great Recession. Results for the full sample are similar (see appendix).[17]

In Panel B, I report returns adjusted for firm characteristics associated with stock returns in the cross section to disentangle a premium for sticky-price firms from well-known cross sectional return predictors. Following Daniel, Grinblatt, Titman, and Wermers (1997), I sequentially sort all common stocks of the CRSP universe into one of 125 benchmark portfolios based on size, industry-adjusted book-to-market, and momentum. I then assign each stock in my sample to a benchmark portfolio based on its size, book-to-market ratio, and previous 12-month return. I calculate benchmark-adjusted returns by subtracting the assigned portfolio returns from the individual stock returns. An adjusted return of zero implies the stock's characteristics explain the total stock return.

Standard stock characteristics cannot explain the return premium for sticky-price firms. We see in Panel B that differences in the frequency of price adjustment still lead to a difference in returns between sticky- and flexible-price firms of 2.1%–5.6% even after controlling for these characteristics. The premium for sticky-price firms is only weakly correlated with return premia for size, book-to-market, or momentum.

For comparison, Panel C reports the average annual returns for the CRSP value-weighted and equally weighted indexes and the size (SMB) and value premia (HML) of Fama and French (1993). The average annual return for the CRSP indexes is 15% and 16.8%, respectively, during my benchmark sample period. The size premium is less than 1% and statistically insignificant, whereas the value premium is 5.6%. The premium for sticky-price firms is therefore economically large and in the order of magnitude of two of the most studied cross-sectional-return premia in finance.

B.   Panel Regressions

A limitation of the portfolio analysis is that returns may differ across portfolios for reasons other than price stickiness, such as heterogeneity in market power or cyclicality of demand. I exploit the rich cross-sectional variation in returns, measured price rigidities, and other firm characteristics to differentiate between these alternative explanations.

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[17]The return premium for sticky-price firms is also not driven by attrition or survivorship bias (see Table A.18 in the appendix).

Specifically, I run panel regressions of annual returns at the firm level, $R_{i,t}$, on the firm-specific measure of price stickiness, SAU_i, firm- and industry-level controls, $X_{i,n,t}$, and year fixed effects, μ_t:

$$R_{i,t} = \alpha + \beta_{SAU_i} \times SAU_i + \sum_n \beta_n \times X_{i,n,t} + \mu_t + \epsilon_{i,t}. \tag{1}$$

Table 4 reports results for annual, non-overlapping percentage returns. Standard errors are clustered at the firm level and reported in parentheses.[18] The coefficient on SAU in column (1) is negative and highly statistically significant.[19] Moving from a firm that never changes product prices to a firm with the most flexible prices leads to a return differential of 6% per year.[20] Adding year fixed effects in column (2) increases the coefficient on SAU in absolute value. In columns (3)–(5), we see that larger firms have lower returns (*size* effect); firms with high book value of equity compared to market value command a positive return premium (*value* effect); and firms with higher βs earn on average higher returns ($CAPM$). Controlling for these factors has little impact on the coefficient on SAU. The coefficient varies between -8.04 and -12.94, which implies a return differential between sticky- and flexible-price firms of 4.8%–7.8% per year. Controlling for additional covariates in columns (6)–(11) has no material effect on the economic or statistical significance of the coefficient of interest. In the last column, I add all explanatory variables jointly. The coefficient on the frequency of price adjustment remains negative and highly statistically significant, contrary to the coefficients on some of the return predictors. The specification with all controls implies an annual return premium of 4.2%. The coefficient on SAU in the panel regressions implies a similar return premium for sticky-price firms as the portfolio analysis in Table 3: the difference in the frequency of price adjustment between the two extreme portfolios of 0.34 (see Table A.4 in the appendix) implies a return differential of 2.4%–4.4%, depending on the controls employed.

Table 5 repeats the baseline analysis at the industry level to control for possibly unobserved industry heterogeneity. This exercise exploits only variation in the frequency of price adjustment within industry. I typically have fewer observations, and thus my

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[18]Clustering standard errors at the firm-year level has little impact; see Table A.15 in the appendix.

[19]The R^2s of firm-level panel regressions are generally small; see also Table A.5 in the appendix for the other covariates.

[20]I calculate this premium by multiplying the regression coefficient on SAU by the difference in the frequency of price adjustment: 10.04×0.6 (see Table 1). The interquartile range in the frequency of price adjustment implies an annual return difference of 1.8%. A one-standard-deviation change in SAU is associated with a differential return of 1.3% per year.

estimates have higher sampling uncertainty. For all industries, I find a negative coefficient on SAU, which is statistically significant for three out of the six industries. These results indicate that unobserved industry characteristics do not drive the baseline effects. Instead of running regressions at the industry level and relying on small sample sizes, I add industry dummies in the last column of Table 5. The coefficient on the frequency of price adjustment is highly statistically significant, economically large, and consistent with previous estimates. Therefore, differences in mean return across industries for reasons orthogonal to the frequency of price adjustment can not explain the return premium for sticky-price firms.

C. Double Sorts

In Table 6, I perform conditional double sorts to allow for non-linear associations between firm characteristics and returns. Specifically, I first sort all stocks into three bins based on a cross-sectional-return predictor. Within each bin, I further sort stocks into three bins based on the frequency of price adjustment. For each category of price stickiness, I then take the average across sorts of the firm characteristics and report them in Table 6. In column (1), for example, I compare firms differing in their frequencies of price adjustment but with similar composition of market capitalization.

In column (0), I report the results of an unconditional sort into tertiles based on the frequency of price adjustment. This sorting generates a statistically-significant return premium for sticky-price firms of more than 3%. Looking at the sorting conditional on size in column (1), we see that returns decrease monotonically in price flexibility. The premium for sticky-price firms after taking out variation in size is 2.5% per year and highly statistically significant. Focusing on the premium across conditioning variables in columns (2)–(9), we see that price stickiness always commands a statistically significant premium between 2.7% and 3.5% per year. These premia are similar in size to the unconditional premium in column (0).

To get a feeling for the magnitude of the return differential, I perform two more conditional double sorts in the last two columns. First, I sort all stocks into three brackets based on size. Second, within each size category, I sort stocks based on β and book-to-market. These sorts generate an annual return differential between high- and low-β stocks and value and growth sorts of 3.5% and 1.8%, respectively, after controlling for size. The conditional premium for high-β stocks is barely statistically significant, and the

conditional value premium is economically small and statistically insignificant.

The premium for sticky-price firms is not driven by linear or non-linear relations with standard cross-sectional-return predictors, and is economically significant.

D.   Exposure to Systematic Risk

D.1   Capital Asset Pricing Model

I perform time-series tests of the CAPM regressing portfolio excess returns, $R^e_{p,t}$, on a constant and the excess returns of the CRSP value-weighted index, $R^e_{m,t}$, to test whether differential exposure to market risk can explain the premium for sticky-price firms

$$R^e_{p,t} = \alpha_p + \beta_p \times R^e_{m,t} + \epsilon_{p,t}.$$

The CAPM predicts that exposure to market risk fully explains the expected excess return, namely, that the α is zero.

Table 7 reports αs in percent per month and βs for the conditional CAPM in Panel A.[21] I report Fama and MacBeth (1973) standard errors in parentheses and Newey and West (1987)-corrected standard errors in brackets.

The conditional CAPM cannot explain the portfolio returns. Monthly αs are positive, economically large, and statistically significant but similar across portfolios. βs monotonically decrease from 1.29 for portfolio 1 to 0.91 for portfolio 5. The conditional CAPM drives the α of the return difference between sticky- and flexible-price firms (column (6), S1-S5) all the way to 0. The difference in annual returns between stocks with high and low frequencies of price adjustment of more than 4% is fully explained by their differential exposure to market risk.

Figure 1 plots the return difference between sticky- and flexible-price firms and the market excess return. The two series track each other closely. Times of low market returns typically coincide with times of low returns for sticky-price firms compared to the returns of flexible-price firms. The unconditional correlation between the two times series is more than 50%.

Sticky-price firms are riskier and therefore earn higher returns than firms with flexible

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[21]I estimate the conditional CAPM monthly on a rolling basis over the previous year, following Lewellen and Nagel (2006). Appendix Table A.7 reports results for an unconditional CAPM.

prices.[22] These findings imply the frequency of price adjustment is a significant predictor of systematic risk.

D.2 Discount-Rate and Cash-Flow News

Differences in the frequency of price adjustment lead to a spread in returns that differential exposure to systematic risk fully explains. The empirical success of the CAPM is surprising because the data generally reject this model.[23] Campbell and Vuolteenaho (2004) argue that variations in the aggregate stock market can occur either due to news about future cash flows or due to news about future discount rates. They derive a decomposition of CAPM β into a cash-flow β, β_{CF}, and a discount-rate β, β_{DR}, and they suggest the price of risk for the covariation with discount-rate news is lower than the price of risk for the covariation with cash-flow news based on the insights of the intertemporal CAPM. Differential exposure to these two sources of fundamental risk can explain why the overall β might not be a sufficient statistic to explain expected returns. High-β stocks can earn lower returns than predicted by the CAPM if most of their overall β is due to the covariation with discount-rate news.

In Table 8, I perform the Campbell and Vuolteenaho (2004) decomposition to investigate why the CAPM performs well in my setting.

I define cash-flow and discount-rate βs as

$$\beta_{p,CF} \equiv \frac{Cov(r_{p,t}^e, N_{CF,t})}{Var(r_{m,t}^e - \mathbb{E}_{t-1} r_{m,t}^e)}$$

$$\beta_{p,DR} \equiv \frac{Cov(r_{p,t}^e, -N_{DR,t})}{Var(r_{m,t}^e - \mathbb{E}_{t-1} r_{m,t}^e)},$$

where $r_{p,t}^e$ is the log excess return of portfolio p, $r_{m,t}^e$ is the log excess return of the market, $N_{CF,t}$ denotes news about future dividends, $N_{DR,t}$ denotes news about future expected returns, and $\mathbb{E}_t$ is the expectation operator conditional on the time t information set. I estimate a VAR with the market excess returns as one of the state variables. The

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[22]Differences in βs fully explain differences in returns in the portfolio analysis, whereas individual firms' βs and the frequency of price adjustment are both individually significant in the panel regressions. Noting that firm-level βs are measured with noise can reconcile this apparent contradiction. The empirical asset-pricing literature has therefore moved away from explaining individual stock returns to explaining returns at the portfolio level sorted on some characteristic of interest (see Fama (1976)).

[23]See, e.g., Black, Jensen, and Scholes (1972) and Frazzini and Pedersen (2013). Lettau, Maggiori, and Weber (2014) show that a simple extension of CAPM, which allows for a separate compensation for downside risk, has high explanatory power across many important asset classes. Unconditional and downstate sensitivities to market risk for my portfolios sorted on the frequency of price adjustment are almost identical and their model boils down to standard CAPM.

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news terms are simple functions of VAR innovations.[24] I calculate GMM (Hansen (1982)) standard errors conditional on the realized news series from the VAR.

We see in column (1) that cash-flow and discount-rate news contribute almost equally to the overall β of the sticky-price portfolio of 1.15: $\beta_{S1,CF}$ is 0.55 and $\beta_{S1,DR}$ is 0.60. Both βs decrease monotonically in the portfolio number to values of 0.41 and 0.44, respectively. The difference in βs between sticky- and flexible-price firms is 0.14 for $\beta_{S1-S5,CF}$, 0.15 for $\beta_{S1-S5,DR}$, and 0.29 for the overall β_{S1-S5}. The difference in discount-rate and cash-flow βs is almost constant across portfolios and varies between 0.03 and 0.04. Sticky price firms have higher exposure to both sources of fundamental risk and are unambiguously riskier than firms with flexible prices. The overall β is therefore sufficient to determine the overall riskiness of a portfolio independent of potentially different prices of risk.

D.3 Monetary Policy Shocks and Portfolio Returns

The previous section shows the mechanism of why the CAPM works: the overall β is a sufficient statistic to describe the cross section of stock returns sorted on the frequency of price adjustment. The economic reason for the good empirical performance lies in the importance of monetary policy for aggregate risk premia in equity markets during my sample period. 60%-80% of the realized equity premium is earned around macroeconomic news announcements such as the press releases of the Federal Open Market Committee (FOMC).[25] Monetary policy surprises are purely nominal shocks and are of particular interest in the context of nominal rigidities. A further advantage of monetary policy shocks is that they are easy to construct, well identified, and are the subject of a substantial literature in macroeconomics and finance. In addition, these shocks are the main driver of risk premia in my model (see Section IV).

Table 9 reports the results from regressing monthly excess returns, $R_{p,t}^e$, of portfolios sorted on the frequency of price adjustment and the CRSP value-weighted index on the surprise component of the one-month change in the Federal Funds rate, Δi_t^u:

$$R_{p,t}^e = \alpha_p + \beta_{p,FFR} \times \Delta i_t^u + \epsilon_{p,t}.$$

The sample is restricted to a period from June 1989 to June 2007 due to the

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[24]See Appendix E. for a detailed discussion and derivation of the key equations.

[25]Bernanke and Kuttner (2005) show that a 1% surprise increase in the Federal Funds rate leads to a drop in the CRSP value-weighted index of more than 11% in monthly time-series regressions. Savor and Wilson (2013) show that 60% of the equity premium is earned around scheduled macroeconomic news announcements, whereas Lucca and Moench (2013) find that 80% of the equity premium since 1994 is earned in the 24 hours before the FOMC press releases.

availability of the Federal Funds futures. The aggregate market falls by more than 9% after a 1% surprise increase in the Federal Funds rate (column (1)). The reaction varies substantially across firms. Sticky-price firms are the most responsive (fall by 11%, column (2)), whereas flexible-price firms fall by only 5% (column (6)).

This differential reaction is broadly in line with the prediction of CAPM. The sticky-price portfolio is predicted to earn -11% following a Federal Funds rate surprise. The predicted sensitivities decrease monotonically in the degree of price flexibility to a predicted drop of 7% for the flexible-price portfolio. Therefore, the CAPM has high explanatory power for the cross section of stocks sorted on the frequency of price adjustment, both unconditionally and conditional on the realization of monetary policy shocks. These results underline the role of the frequency of price adjustment as a strong determinant of the cross section of stock returns and could explain why the CAPM works well around FOMC press releases (Savor and Wilson (2013)).

E. **Business-Cycle Variation in Return Premium**

A large literature in finance documents variation in expected excess returns over time, which is predictable by scaled stock-price ratios. Lustig and Verdelhan (2012) show that excess returns in the United States and other OECD countries are substantially higher during recessions than during expansions. Variation in risk premia leads to variation in the cost of capital of firms to evaluate investment projects and has important implications for asset allocation and market-timing investment strategies.

I perform long-horizon forecasting regressions to test whether the premium for sticky-price firms varies systematically with business-cycle conditions. Specifically, I run m-month forecasting regressions of the cumulative log premium for sticky-price firms, r^e_{lh}, on the proxy for the consumption-wealth ratio of Lettau and Ludvigson (2001), cay[26]

$$\sum_{s=1}^{m} r^e_{lh,t+s} = a_{lh} + b^{(m)}_{lh} dp_t + \epsilon_{t+m}.$$

Table 10 reports regression coefficients for horizons ranging from one month to five years. For each regression, the table reports OLS standard errors in parentheses, Newey and West (1987) standard errors in brackets, Hansen and Hodrick (1980) standard errors in curly brackets, and Hodrick (1992) standard errors in angle brackets.

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[26]Lettau and Ludvigson (2001) use quarterly data from the National Income and Product Accounts to construct cay. To get a monthly series, I linearly interpolate the quarterly observations available under http://faculty.haas.berkeley.edu/lettau/data_cay.html.

cay has strong predictive power for the premium for sticky-price firms at all horizons and explains 60% of the time-series variation at a three-year horizon.[27] In times of a high consumption-wealth ratio, when consumption is high relative to asset wealth, sticky price firms have high expected returns.

Figure 2 plots cay at the end of June along with the subsequently realized five-years return premium for sticky-price firms. The two times series track each other fairly closely. Times of low asset returns and hence high values of cay, typically recessions and stock market downturns, predict a high premium for sticky-price firms. The raw correlation between the two time series is 68.73%.

The results from the long-horizon predictive regressions establish that firms with sticky prices have higher expected returns than firms with flexible prices in recessions and in times of low aggregate stock market returns. The higher cost of capital for these firms in bad times should ceteris paribus lead to lower investment at the firm level and might explain why price rigidities are important for business-cycle variation.[28]

The findings in this section document that the cross-sectional-return premium for firms with sticky product prices is a compensation for risk. The portfolio of stocks with low frequencies of price adjustment has a higher co-movement with the aggregate stock market than the flexible-price portfolio and is more sensitive to monetary policy shocks. The return premium varies systematically with business-cycle conditions and is highly predictable in the time series.

IV   Model

In this section, I develop a dynamic New Keynesian production-based asset-pricing model to test whether the premium for sticky-price firms can be rationalized within such a framework. Households have external habit formation in consumption and derive utility from a composite consumption good and leisure. They provide different labor services and have market power in setting wages. The production side of the economy is organized

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[27]cay has a marginally statistically significant forecasting power for the log excess return of the CRSP value-weighted index, whereas the log dividend-price ratio has no explanatory power for the premium for sticky price firms (see Table A.8 and Table A.9 in the appendix).

[28]The appendix contains additional results and robustness checks, such as panel regression for overlapping and monthly returns, full sample results, regressions on unwinsorized data, results for realized volatilities and for different measures of the frequency of price adjustment. All additional results are similar to those reported in the main body of the paper and discussed in detail in section *F.* of the appendix.

in different sectors producing output according to a technology that is linear in labor. Individual firms in each sector are monopolistically-competitive suppliers of differentiated goods and competitive demanders in the market of homogeneous labor input. I consider a cashless economy with nominal bonds in zero net supply. The monetary authority sets short-term interest rates according to a Taylor rule. In the interest of space I will discuss the model verbally and focus on key equations. Appendix A. contains detailed derivations of the model and Appendix B. summarizes the equilibrium conditions.

A. Firms

There is a continuum of monopolistically-competitive firms divided into different sectors. Firms are indexed by their sector, $k \in [0, 1]$, and by $j \in [0, 1]$. The distribution of firms across sectors is given by the density f on [0,1]. Firms have market power and follow time-dependent pricing rules. The time for price adjustment arrives stochastically. Each period, a fraction $1 - \theta_k$ of firms in sector k adjusts prices. The probability of price adjustment, or Calvo (1983)–rate, is equal across firms in a given sector and is independent of the time the price has been in effect.[29] Firms are demand constrained and satisfy all demand at posted prices. They rent homogeneous labor services, H_t, taking the wage rate, W_t, as given to produce output, $Y_{kj,t}$, according to a linear technology in labor, $H_{kj,t}$. The log of aggregate technology follows an AR(1) process.

The pricing problem of a firm that adjusts in period t is then to set the reset price $X_{kj,t}$ to maximize the expected present value of discounted profits over all future histories in which it will not have a chance to adjust the price

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\theta_k)^s \frac{\Lambda_{t+s}}{\Lambda_t} \left(X_{kj,t} Y_{kj,t+s} - W_{t+s} H_{kj,t+s} \right),$$

subject to its demand function and production technology. Λ_t equals the Lagrange multiplier on the household budget constraint, and β is the time discount factor. Firms charge a constant markup over a weighted average of current and future real marginal costs. Adjusting firms take into account that they might not have a chance to reset prices in future periods. The Calvo probabilities distort the discount factor: the probability that a price set today will still be in effect in period t+s is θ_k^s. Adjusting firms set prices optimally, taking the prices of other firms and aggregate prices as given. All price

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[29]The Calvo model is the workhorse New Keynesian model because it is tractable and easily allows aggregation. Modeling price adjustment in a state-dependent framework instead of a time-dependent fashion has similar implications for macroeconomic aggregates in times of low and stable inflation (see Dotsey, King, and Wolman (1999)).

adjusters in a given sector choose identical prices by the symmetry of the problem.

The value of the firm with current price $P_{kj,t}$ can be written as a simple function of sector k variables:

$$V(P_{kj,t}) = \mathbb{E}_t \left\{ \frac{1}{\lambda_t} P_t \left[RS_{k,t} \left(\frac{P_{kj,t}}{P_t} \right)^{1-\varepsilon_{ck}} - CS_{k,t} \left(\frac{P_{kj,t}}{P_t} \right)^{-\varepsilon_{ck}} + RF_{k,t} - CF_{k,t} \right] \right\}, \quad (2)$$

where $RS_{k,t}$, $CS_{k,t}$, $RF_{k,t}$, and $CF_{k,t}$ are the revenues (R) and costs (C) coming from expected price stickiness (S) and flexibility (F), respectively, and ε_{ck} is the elasticity of substitution of within-sector consumption varieties.

B.   Households

There is a large number of identical, infinitely lived households. Households have a love for variety and derive utility from many different consumption goods. Each household supplies all types of differentiated labor services, $h_{i,t}, i \in [0,1]$.

The representative household has additively separable utility in consumption and leisure and maximizes

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left[\frac{(C_{t+s} - bC_{t+s-1})^{1-\gamma}}{1-\gamma} - \psi_L \int_0^1 \frac{h_{i,t+s}^{1+\sigma}}{1+\sigma} di \right],$$

subject to a flow budget constrained. C_t is the composite consumption good, $b \geq 0$ is a habit-persistence parameter in consumption, $h_{i,t}$ denotes hours worked of type i, and $\psi_L \geq 0$ is a parameter. Profits are redistributed via lump-sum transfer at the end of each period. The parameters γ and σ denote the coefficient of relative risk aversion and the inverse of the Frisch elasticity of labor supply, respectively. The per-period budget constraint equalizes total consumption expenditure and total disposable income, which consists of labor income from the different labor types, and gross payoffs from previous-period bond holdings net of new bond purchases plus aggregate dividends. The composite consumption good is a double Dixit-Stiglitz aggregate of many individual goods produced in different sectors.

C.   Wage Rate

The structure of the labor market follows Erceg, Henderson, and Levin (2000). The representative household sells labor services to a representative, competitive labor aggregator. The aggregator transforms the different labor types into aggregate labor input, H_t. Homogeneous labor is a Dixit-Stiglitz aggregate of the different labor types. For each labor type i, a monopoly union represents all workers of this type. Individual

unions set wages optimally, subject to a Calvo–style wage friction.

The optimization problem of adjusting unions is given by

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\theta_w)^s \left\{ -\psi_L \frac{h_{i,t+s}^{1+\sigma}}{1+\sigma} + \frac{\Lambda_{t+s}}{\Lambda_t} U_{i,t} h_{i,t+s} \right\},$$

subject to the demand curve for labor type i. $1-\theta_w$ equals the Calvo-wage rate and $U_{i,t}$ is the optimal reset wage.

Unions set wages to equalize the expected discounted marginal disutility of providing one additional unit of labor to its expected discounted utility. Again, the optimal reset wage is identical for all unions resetting wages in period t.

Wage stickiness increases the level of the equity premium in the model. Dividends equal output minus wages. In an economy with frictionless labor markets, wages equal the marginal product of labor and are therefore perfectly correlated with output. A drop in demand leads to a drop in output, but at the same time, it also decreases the wage bill. Hence, dividends exhibit too little variation in any reasonable calibration. The Calvo–style wage-setting friction de-couples the average wage paid by a firm from the marginal product of labor. In times of low output and high marginal utility, the wage rate of some labor types cannot be adjusted downward. Firms therefore have to incur higher wages in bad times. This mechanism makes claims on dividends risky and boosts the level of the equity premium.[30]

D. Monetary Policy

The monetary authority sets the short-term nominal interest rate according to

$$i_t = \phi_\pi \pi_t + \phi_x x_t + \log\left(\frac{1}{\beta}\right) + u_{m,t},$$

where i_t is $\log R_t$, $\pi_t = \log P_t - \log P_{t-1}$ is aggregate inflation, $x_t = \log Y_t - \log Y_{t-1}$ growth in output, ϕ_π and ϕ_x are parameters, and $u_{m,t}$ is a monetary policy shock. The policy shock follows an AR(1) process.

E. Equilibrium

General equilibrium is defined by the optimality conditions for the household utility-maximization problem, by every firm kj's profit optimization, by market clearing in the product, labor, and financial markets, and by rational expectations.

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[30]Wage stickiness is equal across sectors and therefore primarily affects the level of the equity premium. A constant degree of wage stickiness across industries seems justified given the findings Barattieri, Basu, and Gottschalk (2014) of little heterogeneity in the frequency of wage adjustment across industries.

F.   Inefficiency

Knowledge of aggregate labor input, L_t, is not sufficient to determine aggregate output. Cross-sectional dispersion of wage rates across different labor types and product prices within and across sectors increase the required amount of labor input for the production of a given level of the aggregate output index. Different labor types are imperfect substitutes in production, whereas different consumption varieties are imperfect substitutes in the consumption index. As each labor type enters the labor aggregator and the household's utility function symmetrically, optimality requires equal hours across types. Equivalently, as different consumption varieties enter the consumption index symmetrically and firms face identical production technologies, an optimal allocation requires equal production across firms. After a shock, some firms and unions are unable to adjust their product prices and wages, respectively, which leads to dispersion in prices and wages. Wage dispersion across different labor types increases the required amount of labor types for a given level of homogeneous labor. Price dispersion increases the required amount of homogeneous labor for a given level of the output index. Price and wage dispersion and hence *aggregate inefficiency* increase in the curvature of the respective aggregators, that is, the elasticity of substitution across different labor types and the elasticities of substitution of consumption within and across sectoral varieties. *Inefficiencies across sectors* are driven by the elasticity of substitution of consumption varieties within sector as wage dispersion is identical across sectors. The more elastic the demand is for varieties of a given sector and the lower the frequency of price adjustment, the larger the price dispersion (see Woodford (2003)).

G.   Calibration

I calibrate a five-sector version of the model at the quarterly frequency to compare the implications of the model to my empirical findings. I use standard parameter values in the literature.[31] Specifically, the time discount factor β is 0.99, implying an annual risk-free rate of 4% in the non-stochastic steady state. I employ the estimate for the habit-persistence parameter $b = 0.76$ from Altig, Christiano, Eichenbaum, and Linde (2011). I set the parameters of the utility function $\gamma = 5$ and $\psi = 1$ following Jermann (1998) and Altig et al. (2011), and I calibrate the inverse of the Frisch elasticity of labor supply, σ, to a value of 2.5. I set the elasticity of substitution of within-sector consumption varieties

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[31]See Table A.10 in the appendix.

and across sectoral subcomposites, ε_{ck} and ε_c, to values of 12 and 8, respectively, following Carvalho (2006). The sectoral elasticity implies a steady-state markup of roughly 9%, in line with empirical evidence by Burnside (1996) and Basu and Fernald (1997). I follow Erceg et al. (2000) and set θ_w to a value of 0.825. This value implies an average duration of wage contracts of five quarters. ε_w is calibrated to a value of 8, which corresponds to a wage markup of 14% in the range of estimates used in the literature.[32] I set the parameter values of the monetary policy reaction function, ϕ_π and ϕ_y, to standard values of 1.24 and 0.33/4, respectively, in line with results reported in Rudebusch (2002). I use the empirical distribution of the frequencies of price adjustment of Nakamura and Steinsson (2008) to calibrate $\langle 1 - \theta_k \rangle_{k=1}^{5}$. In particular, I sort industries by their frequency of price adjustment and construct five synthetic sectors. The sectors correspond to the quintiles of the distribution of the frequency of price adjustment observed in the data. Each sector covers one fifth of consumer spending. The Calvo rates of price adjustment range from 0.105 to 0.985 per quarter. I calibrate the autoregressive parameters of the two shock processes to $\rho_a = 0.95$ for the technology shock and $\rho_m = 0.90$ for the technology shock – well within the range of empirical estimates (e.g., Smets and Wouters (2007) and Coibion and Gorodnichenko (2012)). I set the standard deviations of the shocks, σ_a and σ_{mp}, to 0.0085 to match the historical standard deviation of log quarterly real gross domestic product (GDP) for my sample period.[33]

In the benchmark case, I solve the model numerically using a second-order approximation as implemented in *dynare*, and simulate the model for 400 firms in each sectors and 500 periods, discarding the first 250 periods as burn in.[34] For each firm and time period, I then calculate the firm value, $V(P_{kj,t})$, dividends, $D(P_{kj,t})$, and returns as $R_{kj,t} = \frac{V(P_{kj,t})}{V(P_{kj,t-1}) - D(P_{kj,t-1})}$.

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[32] Altig et al. (2011) set the wage markup to 5%, whereas Erceg et al. (2000) calibrate ε_w to 4, implying a markup of 33%. As displayed in Table 11, results are not very sensitive to changes in this parameter.

[33] I download seasonally adjusted real GDP in billions of chained 2009 dollars from the FRED database. Consistent with findings of Gorodnichenko and Ng (2010), I apply the Hodrick-Prescott filter with a smoothing parameter of 1600 to both historical and model-generated data to calibrate the shock standard deviations.

[34] I employ the pruning package of Andreasen, Fernández-Villaverde, and Rubio-Ramírez (2014) to ensure the simulated sample paths do not explode. Pruning leaves out terms of higher order than the approximation order.

G.1 Simulation Results

Table 11 reports annualized mean excess returns over the risk-free rate at the sector level, the spread in mean returns between the portfolios containing firms with low and high frequencies of price adjustment, and the annualized equity risk premium and Sharpe ratio, as well as the regression coefficient of annualized returns at the firm level on the monthly frequency of price adjustment.

The baseline calibration in line (1) results in annualized excess returns of almost 8% for the sticky-price sector. Excess returns decrease monotonically in the degree of price flexibility to as low as 5.5% for the flexible-price sector. The return premium for sticky price firms is almost 2.4% per annum, in line with my empirical findings in Table 4. The model displays an equity premium of 6.6% and an annual Sharpe ratio of 0.39. The coefficient of annual firm-level returns on the frequency of price adjustment is negative and highly statistically significant. The coefficient implies that moving from a firm with totally sticky prices to a firm with totally flexible prices is associated with a decrease in annual returns of 2.5% per annum.

The baseline calibration documents that heterogeneity in the frequency of price adjustment leads to a cross-sectional difference in returns. The following lines of Table 11 evaluate the robustness of this finding and carve out the key driving forces behind this result. Lines (2)–(5) investigate the effect of variations in the within- and across-sector elasticities on the equity premium and the return differential. In lines (2) and (3), we see that changes in ϵ_{ck} have an immediate effect on the premium for sticky-price firms while hardly affecting the overall level of the equity premium. In particular, increasing ϵ_{ck} from a baseline value of 12 to 13 increases the cross-sectional difference in returns by almost 50%. On the other hand, varying the across-sector elasticity of substitution (lines (4) and (5)) has only small effects on the level of the risk premium or the cross-sectional-return difference. In lines (6) and (7), we see that lowering the elasticity of substitution between different labor types has only negligible effects, whereas calibrating the Frisch elasticity of labor supply to a value of 1 increases both the cross-sectional spread in returns and the overall equity premium.

In the next exercise, I evaluate the effects of higher aggregate risk. Specifically, I increase the standard deviations for both the monetary policy and the technology shocks. Higher aggregate risk increases the returns for all sectors, but disproportionately for

sectors with lower frequencies of price adjustment. The premium for sticky-price firms doubles and the equity premium increases by almost 1% per year.

Lines (9) and (10) check how changes in the responsiveness of monetary policy affect the findings. A more aggressive stance on inflation dampens the equity premium by 1% and reduces the dispersion in returns across sectors by a factor of 4. Changes in the reaction to output growth, however, have little impact on stock returns. Lines (11) and (12) disentangle the contributions of the two shocks: the cross-sectional and the level effects are almost exclusively driven by monetary policy shocks. Increasing the persistence of technology shocks in line (13) increases the cross-sectional premium for price stickiness and the overall level of the equity premium.

G.2 **Two-Sector Model**

To gain a better understanding of the different margins behind the cross-sectional-return premium, I work with a two-sector version of the model in the following. The advantage of the two-sector model is that I can directly relate movements in aggregate variables to movements in the sticky- and flexible-price sectors.

Instead of simulating dividends and valuations at the firm level, I report returns for a claim on aggregate dividends at the sector level. I show in the appendix that sector dividends are given by sector output times the sector profit margin, which can be expressed as the sector markup, $\mu_{k,t}$, minus 1 over the markup. I can decompose the markup further into a relative price and a price dispersion component

$$D_{k,t} = Y_{k,t} \left[1 - \left(\frac{W_t}{P_t} \right) \left(\frac{1}{A_t} \right) \left(\frac{P_{k,t}}{P_t} \right)^{-1} DS_{p,k,t} \right].$$

Expressing this relation in percentage deviations from steady state

$$\check{D}_{k,t} = \check{Y}_{k,t} - \frac{Y_k - D_k}{D_k} \left[\left(\frac{\check{W}_t}{P_t} \right) - \check{A}_t - \left(\frac{\check{P}_{k,t}}{P_t} \right) + \check{DS}_{p,k,t} \right]. \tag{3}$$

Differences in sector dividends, $\check{D}_{1,t} - \check{D}_{2,t}$, are therefore determined by three margins: (i) a quantity margin, $(\check{Y}_{1,t} - \check{Y}_{2,t})$; (ii) a relative price margin, $(\check{P}_{1,t} - \check{P}_{2,t})$; and (iii) an inefficiency or price-dispersion margin, $-(\check{DS}_{p,1,t} - \check{DS}_{p,2,t})$. The quantity margin captures the sensitivity of sectoral output to price differentials across sectors, which is the price margin, whereas the inefficiency margin reflects lost output due to dispersion in prices.

Figure 3 graphically analyzes the cross-sectional-return premium for sticky-price firms. I plot the average difference in dividends between the sectors with low and high frequencies of price adjustment, $(Div_{sticky} - Div_{flexible})$, and marginal utility,

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$(C_t - bC_{t-1})^{-\gamma}$, as a function of aggregate output. I simulate the model 500 times, sort the difference in sector dividends and marginal utility based on the realization of aggregate output, and take the average across simulations. In times of low aggregate output and high marginal utility, the sector with low frequency of price adjustment has lower dividends than the flexible price sector. Negative relative payoffs in times of high marginal utility are key for a positive return premium for sticky-price firms.

Figure 4 plots the impulse response functions of several aggregate and sector-level variables to a one-standard-deviation monetary policy shock. Contractionary monetary policy shocks lead to a drop in real output, Y; inflation, π, and the aggregate real-wage rate, w, decrease, whereas marginal utility, λ, goes up. The drop in real wages is less than the drop in output, and the increase in marginal utility is an order of magnitude larger in absolute value due to the stickiness of wages and habit formation.

In terms of dividends, firms in the sticky-price sector are on average stuck at their current price. The relative price of sector 1, $P1$, increases compared to sector 2, in line with the real reset price of sector 1, $X1$. The next line of Figure 4 shows an increase in price dispersion, DS. The dispersion in prices is substantially larger for the sticky-price sector. We see in line 6 that the drop in aggregate output, Y, leads to a decrease in output at the sector level, $Y1$ and $Y2$. The decline in output for the sticky-price sector is larger compared to sector 2 due to the higher relative price. We see in the last lines of the figure that contractionary monetary policy leads to a drop in sector dividends, $D1$ and $D2$, stock prices, $S1$ and $S2$, and returns, $Ret1$ and $Ret2$. Negative payoffs in times of high marginal utility is the key condition for a positive equity premium.

Firms in the stick-price sector gain along the price margin compared to firms in the flexible-price sector but lose along the quantity and inefficiency margins. All three margins combined result in lower sector dividends, D, stock prices, S, and returns, Ret, for firms in sector 1 compared to flexible-price firms.

Figure 4 also plots impulse response functions for different values of the elasticity of substitution of within-sector consumption composites to gain intuition for the effects of ε_{ck} on the premium for sticky-price firms documented in Table 11.[35] The disadvantage for sticky-price firms in the quantity margin and the advantage in the price margin decrease in the elasticity of substitution of within-sector consumption varieties. The negative effect

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[35]ε_{ck} low, medium, and high correspond to values of 8, 12, and 16, respectively. The premium for sticky-price firms increases from 0.92% to 6.73% per year.

of price dispersion on dividends increases in ε_{ck}. Taken together, the effects on the price and price-dispersion margins are quantitatively more important. The difference in sector dividends decreases and the premium for sticky-price firms increases in ε_{ck}.

I show in the appendix that the elasticity of substitution of consumption varieties across sectors, ε_c, only affects the quantity margin $(\check{Y}_{1,t} - \check{Y}_{2,t})$. Increasing ε_c translates into larger negative differences in dividends between the sticky- and flexible-price sector and therefore increases the premium for sticky-price firms. This channel, however, is quantitatively small and of second order compared to the effects of ε_{ck}.[36]

A dynamic New Keynesian asset-pricing model therefore is consistent with the novel empirical findings, a large premium for sticky-price firms that varies over the business cycle, and an equity premium in line with historical estimates.

V   Conclusions

Sticky prices have a long history in such different fields as macroeconomics, industrial organization, and marketing, and are key to explaining the business-cycle dynamics of real gross domestic output, consumption, and investment. I document that price rigidities are also a strong predictor of the cross section of stock returns. CAPM βs are a function of many parameters and factors, and we have little knowledge about the fundamental drivers. The frequency of product-price adjustment is a simple statistic at the firm level that can account for a considerable part of the variation of firms' exposure to systematic risk. To the extent that firms equalize the costs and benefits of price adjustment, the higher cost of capital for sticky-price firms reflects a holistic measure of the total costs of sticky prices. Therefore, price rigidities are important both business-cycle dynamics in aggregate quantities and cross-sectional variation in stock returns, and further bridge macroeconomics and finance.

I document that a dynamic New Keynesian asset-pricing model in which firms differ in their frequency of price adjustment is consistent with my novel stylized facts. A sufficiently high elasticity of substitution between consumption varieties within sectors, ε_{ck}, is the central condition for large premium for sticky price firms. Three margins determine the cross-sectional-return difference: a quantity margin, a price margin, and an inefficiency

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[36]In the appendix, I also study why technology shocks only lead to a small premium, and document substantial business-cycle variation in the premium for sticky-price firms in simulated data.

margin associated with price dispersion. Whereas the first margin ceteris paribus lowers the return premium, the other two margins increase the difference in returns between sticky- and flexible-price firms with increasing ε_{ck}.

There are several potential extensions for future research. Labor is the only production factor in my current setup. Allowing for capital and investigating how investment at the firm level interacts with price stickiness would be interesting.[37] New Keynesian models have strong predictions on how production is distributed across firms and sectors after aggregate shocks, with interesting implications for firm-level investment. Furthermore, the current setup completely abstracts from capital-structure considerations. It assumes firms are fully equity-financed. The positive correlation between leverage and the frequency of price adjustment indicates that a departure from this assumption could be a fruitful avenue for future research. In addition, my current analysis neglects potential heterogeneity in wage stickiness across firms and industries. The importance of wage stickiness for the aggregate level of equity risk premia and the interaction with price stickiness underlines the importance of this question for future research. Ultimately, the cause of sticky prices and the determinants of differences in the frequency of price adjustment across firms within industry are the vital questions for future research.

Using information contained in asset pricing more generally is a fruitful avenue for future research. Starting with Lucas (1987), researchers have used the information content of stock prices to calculate the welfare cost of business-cycle fluctuations. Gorodnichenko and Weber (2013) employ information from stock returns to distinguish between alternative macro models for the observed level of price stickiness in micro data, whereas information in credit spreads can potentially be useful for identifying the cost of inflation uncertainty.

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[37]To get interesting macro and asset-pricing implications, one has to depart from the convenient modeling tool of economy-wide rental markets for capital (see, e.g., Altig et al. (2011) and Lettau and Uhlig (2000)) and allow for firm-specific capital.

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Figure 1: **Market Excess Return and Sticky minus Flexible Price Portfolio**
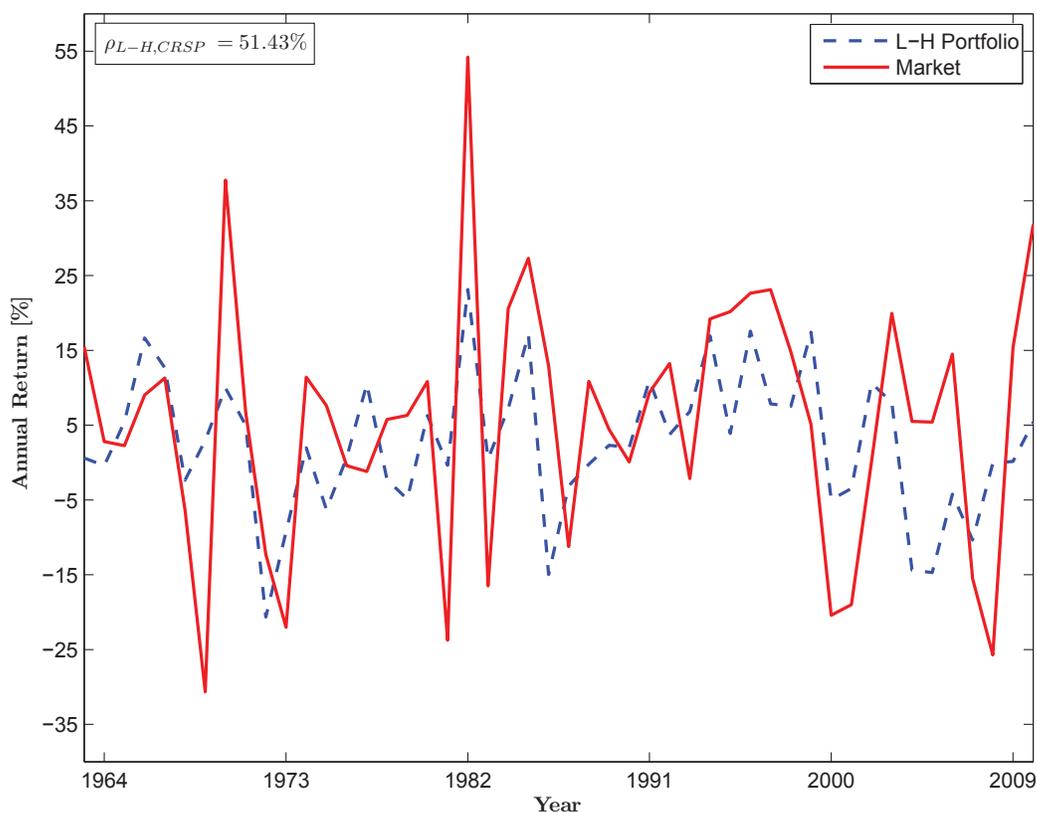
This figure plots the annual excess return of the CRSP value-weighted index (market) and the annual return of the zero-cost portfolio of going long the portfolio of stocks with low frequencies of price adjustment and shorting the portfolio of stocks with high frequencies of price adjustment, L-H. The sampling frequency is annual. The sample period is July 1963 to June 2011.

Figure 2: **Consumption Wealth Ratio (cay) and Following 5 Years Returns**
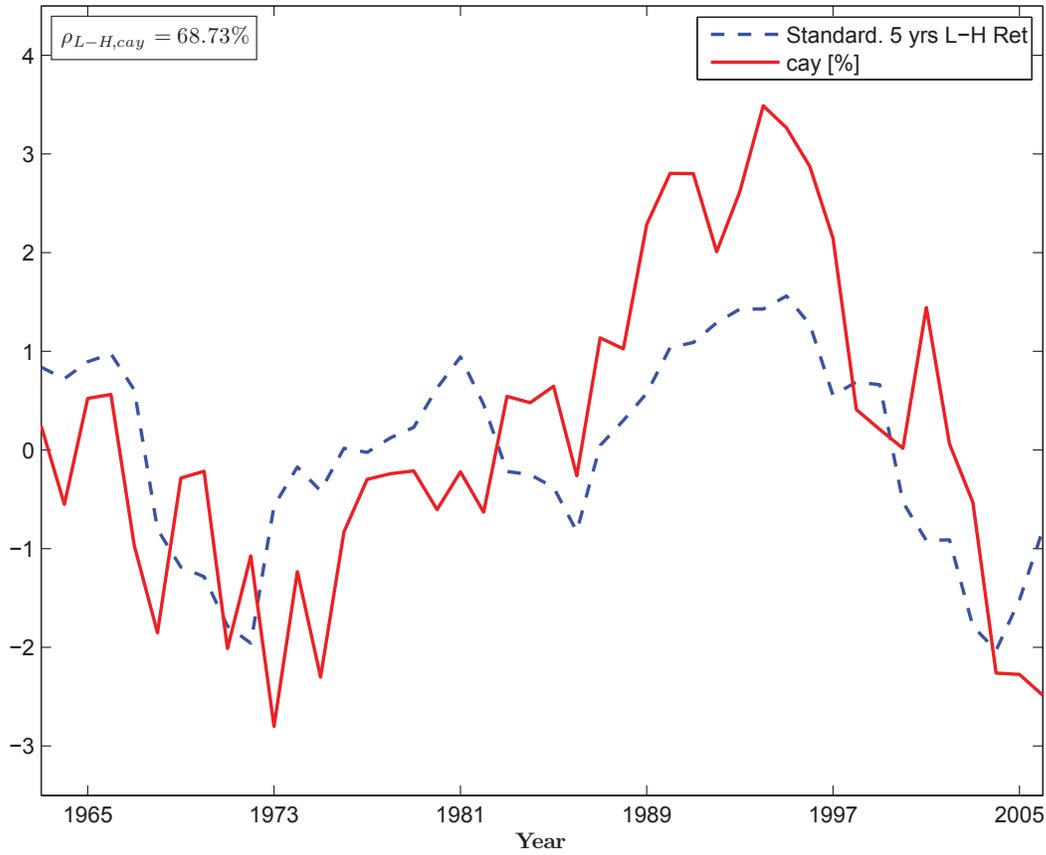
This figure plots the Lettau and Ludvigson (2001) proxy for the consumption wealth ratio, cay, and the subsequently realized five years return of the zero-cost portfolio of going long the portfolio of stocks with low frequencies of price adjustment, and shorting the portfolio of stocks with high frequencies of price adjustment, L-H. The sampling frequency is annual with cay observed at end of June of year t and returns measured from July of year t to June of year t+5. The sample period for cay is June 1963 to June 2006.

Figure 3: **Difference in Sector Dividends and Marginal Utility**
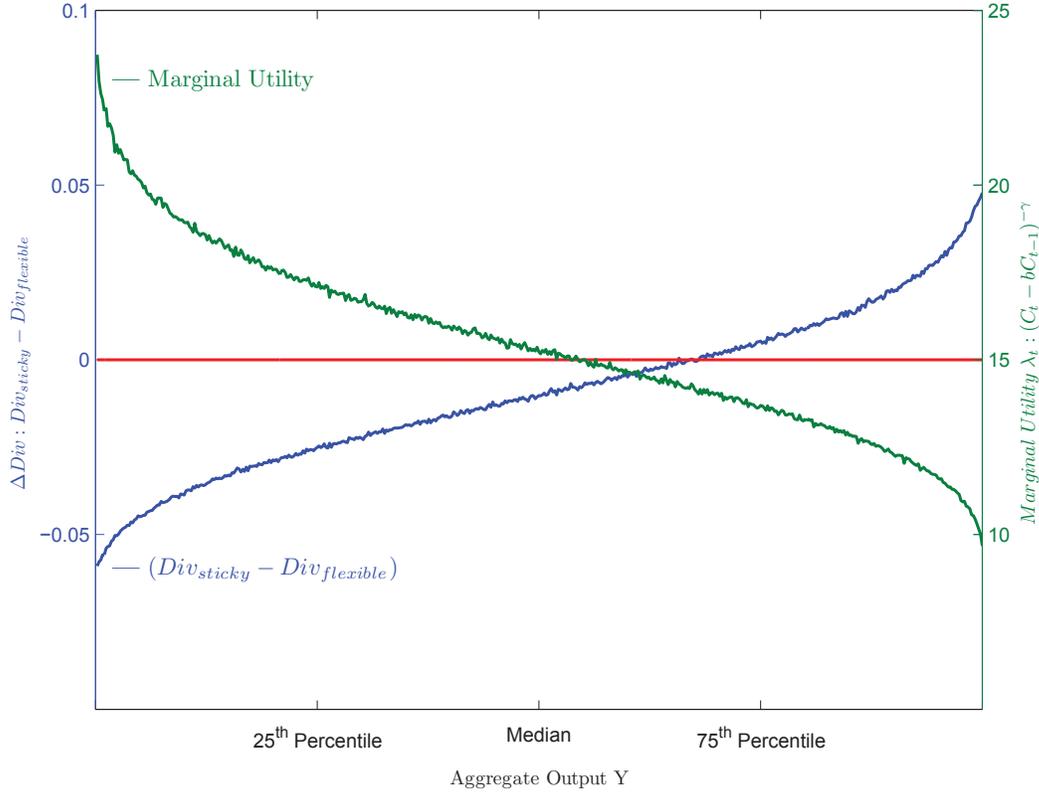
This figure plots the average difference in dividends of the sectors with low and high frequencies of price adjustment, $(Div_{sticky} - Div_{flexible})$, and marginal utility, $(C_t - bC_{t-1})^{-\gamma}$, as a function of aggregate output, Y. I simulate a two sector version of the model of Section IV 500 times, sort the difference in sector dividends and marginal utility based on the realization of aggregate output and take the average across simulations. The difference in dividends is measured on the left y-axis whereas marginal utility is measured on the right y-axis.

Figure 4: **Impulse Response Functions to Monetary Policy Shock (varying ε_{ck})**
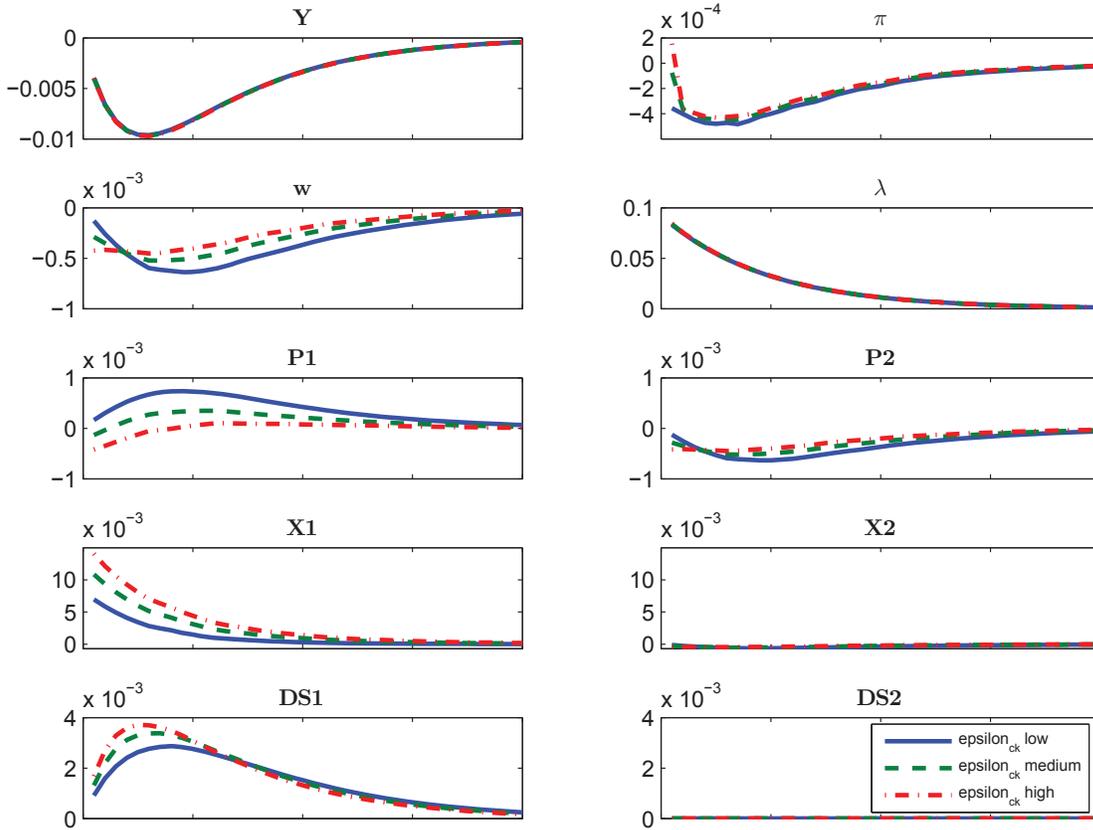
This figure plots the impulse response functions of several macroeconomic variables of the model of Section IV to a one-standard-deviation contractionary monetary policy shock for different values of the elasticity of substitution of within-sector consumption varieties, ε_{ck}. ε_{ck} low, medium, and high correspond to values of 8, 12, and 16, respectively. Y is output, π, inflation, w, aggregate real wage, λ the marginal utility of consumption, P1 and P2, the relative prices of sectors one and two, X1 and X2, the optimal real reset prices, and DS1 and DS2 the price dispersions in the two sectors.

Figure 5: **Impulse Response Functions to Monetary Policy Shock (varying ε_{ck})**
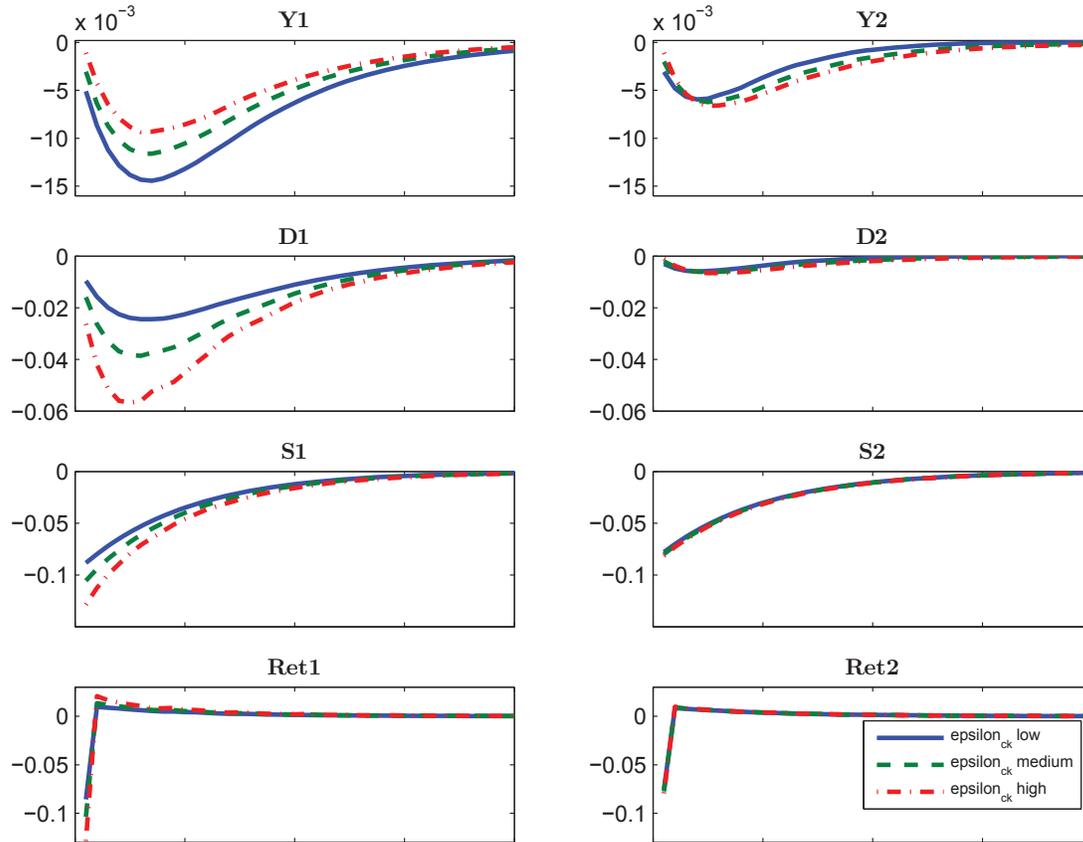
This figure plots the impulse response functions of several macroeconomic variables of the model of Section IV to a one-standard-deviation contractionary monetary policy shock for different values of the elasticity of substitution of within-sector consumption varieties, ε_{ck}. ε_{ck} low, medium, and high correspond to values of 8, 12, and 16, respectively. Y1 and Y2 are the output of the sectors, D1 and D2 are sector-level dividends, S1 and S2 are the prices of claims to aggregate sector dividends, and Ret1 and Ret2 are the returns of these claims.

Table 1: **Frequency of Price Adjustment by Industry**

This table reports equally weighted average monthly frequencies of price adjustment, SAU, at the industry and aggregate levels with standard deviations in parentheses. Frequencies of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. The sample period is July 1963 to June 2011.

	Agriculture	Manufacturing	Utilities	Trade	Finance	Service	Total
Mean	22.75%	12.03%	22.66%	20.41%	13.14%	8.13%	14.86%
Std	(17.49%)	(11.35%)	(12.79%)	(13.74%)	(11.31%)	(9.19%)	(13.00%)
Max	59.39%	60.00%	53.89%	60.00%	45.65%	60.00%	60.00%
Min	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N	16,754	139,235	42,425	19,124	40,380	15,618	273,536

Table 2: **Summary Statistics and Correlations for Characteristics and Return Predictors (Benchmark Sample)**

This table reports time-series averages of annual cross-sectional means and standard deviations for firm characteristics and return predictors used in the subsequent analysis in Panel A and contemporaneous correlations of these variables in Panel B. SAU measures the frequency of price adjustment. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. Size is the natural logarithm of the market capitalization in thousands, BM is the book-to-market ratio, Beta is the regression coefficient on the market excess return in rolling times-series regressions, Lev is financial leverage, CF measures cash flows, Turnover is the fraction of shares traded to shares outstanding, spread is the mean bid - ask spread, PCM is the price-to-cost margin, and HHI is the Herfindahl - Hirschman index of sales at the Fama & French 48 industry level. Stock-level data are from CRSP and financial statement data are from Compustat. The sample period is July 1982 to June 2007.

	SAU	Size	BM	Beta	Lev	CF	Turnover	Spread	PCM	HHI
				Panel A. Means and Standard Deviations						
Mean	0.14	14.76	0.63	1.09	0.40	0.09	10.43	1.31	0.37	0.13
Std	0.13	1.25	0.37	0.42	0.23	0.06	8.34	0.64	0.18	0.32
N	554	554	545	534	551	551	554	554	551	530
				Panel B. Contemporaneous Correlations						
Size	0.07									
BM	0.26	−0.14								
Beta	−0.16	−0.18	−0.26							
Lev	0.17	0.00	0.26	−0.20						
CF	−0.04	0.18	−0.44	0.02	−0.50					
Turnover	−0.03	−0.18	−0.10	0.46	−0.17	0.05				
Spread	0.02	−0.30	0.13	0.11	0.07	−0.14	−0.01			
PCM	−0.16	0.11	−0.34	0.12	−0.09	0.28	0.10	−0.13		
HHI	−0.06	0.04	−0.06	−0.04	0.01	0.09	−0.06	0.01	0.01	

Table 3: **Mean Portfolio Returns (SAU)**

This table reports time-series averages of annual equally weighted portfolio raw returns in Panel A and characteristic-adjusted (DGTW) returns following Daniel et al. (1997) in Panel B for various sample periods with Newey and West (1987) standard errors in parentheses. Stocks are assigned to one of five baskets based on the frequency of price adjustment, SAU. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. Panel C reports time-series averages of annual returns for the CRSP value-weighted index (CRSP VW), the CRSP equally-weighted index (CRSP EW), the size (SMB), and value (HML) factors of Fama and French (1993).

	Sticky	S2	S3	S4	Flexible	S1-S5
Panel A. Annual Mean Returns						
07/1963 - 06/2011	18.84***	18.42***	18.26***	16.97***	16.10***	2.74*
	(2.85)	(2.02)	(2.03)	(2.19)	(1.97)	(1.46)
07/1982 - 06/2007	24.22***	21.98***	22.03***	21.00***	19.84***	4.38 **
	(3.08)	(2.66)	(2.35)	(2.46)	(2.47)	(1.91)
07/1982 - 06/1998	28.77***	25.59***	25.20***	24.39***	22.05***	6.72***
	(3.53)	(2.93)	(3.23)	(2.64)	(2.89)	(1.61)
Panel B. Annual DGTW-adjusted Returns						
07/1963 - 06/2011	4.42***	4.50***	4.14***	3.01***	2.34***	2.08*
	(1.32)	(0.52)	(0.40)	(0.49)	(0.81)	(1.26)
07/1982 - 06/2007	6.81***	5.39***	4.36***	4.09***	3.11***	3.71 **
	(1.09)	(0.27)	(0.69)	(0.63)	(1.13)	(1.63)
07/1982 - 06/1998	6.93***	4.97***	3.60***	3.03***	1.29***	5.64***
	(0.51)	(0.39)	(0.38)	(0.36)	(0.54)	(0.91)

	CRSP VW	CRSP EW	SMB	HML	
Panel C. Annual Factor Returns					
07/1963 - 06/2011	11.28***	15.77***	3.37 **	5.10***	
	(2.12)	(2.08)	(1.58)	(1.04)	
07/1982 - 06/2007	14.99***	16.75***	0.80	5.64***	
	(2.81)	(2.40)	(1.67)	(1.60)	
07/1982 - 06/1998	19.52***	17.77***	−1.50	4.63***	
	(2.61)	(3.58)	(1.15)	(1.13)	

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 4: Panel Regressions of Annual Stock Returns on Price Stickiness and Firm Characteristics (Benchmark Sample)

This table reports the results of regressing annual percentage returns on the frequency of price adjustment, SAU, firm characteristics, return predictors, and year fixed effects, where indicated. Standard errors are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. Size is the natural logarithm of the market capitalization in thousands, BM is the book-to-market ratio, Beta is the regression coefficient on the market excess return in rolling times-series regressions, Lev is financial leverage, CF measures cash flows, Turnover is the fraction of shares traded to shares outstanding, Spread is the mean bid - ask spread, PCM is the price-to-cost margin, and HHI is the Herfindahl - Hirschman index of sales at the Fama & French 48 industry level. Stock-level data are from CRSP and financial statement data are from Compustat. The sample period is July 1982 to June 2007.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
SAU	−10.04***	−10.97***	−8.04***	−12.94***	−8.54***	−10.99***	−10.98***	−9.83***	−10.16***	−9.52***	−10.79***	−7.07***
	(2.16)	(2.28)	(2.44)	(2.50)	(2.29)	(2.32)	(2.31)	(2.27)	(2.34)	(2.25)	(2.36)	(2.73)
Size			−4.38***									−4.97***
			(0.29)									(0.33)
BM				3.22***								3.21***
				(0.84)								(1.11)
Beta					4.12***							0.10
					(0.75)							(1.06)
Lev						1.06						4.35**
						(1.38)						(1.84)
CF							−10.97**					3.76
							(5.55)					(7.49)
Turnover								52.39***				37.00***
								(3.87)				(4.94)
Spread									−5.45***			−7.37***
									(0.54)			(0.57)
PCM										5.61***		7.84***
										(1.66)		(1.98)
HHI											0.23	1.79*
											(0.70)	(0.99)
Year Fixed Effects	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	13,810	13,810	13,810	13,582	13,319	13,735	13,746	13,810	13,810	13,744	13,210	13,029
R^2	0.11%	19.96%	21.99%	20.07%	20.37%	19.86%	19.88%	21.45%	20.99%	19.93%	19.80%	24.93%

Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 5: **Panel Regressions of Annual Stock Returns on Price Stickiness (Benchmark Sample, within Industry)**

This table reports the results of regressing annual percentage returns on the frequency of price adjustment, SAU, year fixed effects, and industry fixed effects, where indicated. Standard errors are clustered at the firm level and reported in parentheses. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. The sample period is July 1982 to June 2007.

	Baseline	Agriculture	Manufacturing	Utilities	Trade	Finance	Services	Dummies
SAU	-10.97***	$-15.28**$	-7.34*	$-9.13**$	-9.35	-2.32	-11.38	-7.80***
	(2.28)	(6.96)	(4.17)	(4.18)	(8.92)	(4.89)	(19.63)	(2.44)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Industry Fixed Effects	N	N	N	N	N	N	N	Y
Observations	13,810	753	6,811	2,029	1,051	2,249	917	13,810
R^2	19.96%	27.15%	20.50%	25.51%	38.89%	44.58%	21.07%	20.24%

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 6: **Mean of Double Sortings**

This table reports average annual returns for double-sorted portfolios. I first assign stocks into tertiles based on various firm characteristics, and then within each portfolio I assign stocks into tertiles based on the frequency of price adjustment, SAU. I report mean returns across characteristic sorts for the sticky-, intermediate-, and flexible-price portfolios as well as the conditional premium for sticky-price firms. Newey and West (1987) standard errors are reported in parentheses. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. Size is the natural logarithm of the market capitalization in thousands, BM is the book-to-market ratio, Beta is the regression coefficient on the market excess return in rolling times-series regressions, Lev is financial leverage, CF measures cash flows, Turnover the fraction of shares traded to shares outstanding, Spread is the mean bid - ask spread, PCM is the price-to-cost margin, and HHI is the Herfindahl - Hirschman index of sales at the Fama & French 48 industry level. Stock-level data are from CRSP and financial statement data are from Compustat. The last two columns report results for conditional double sorts of Beta and BM on size. The sample period is July 1982 to June 2007.

	Uncond	Size	BM	Beta	Lev	Spread	PCM	Turnover	CF	HHI	Beta cond Size	BM cond Size
Sticky	23.32	21.56	22.08	21.89	22.07	21.83	22.20	21.51	21.92	21.75	19.83	22.22
S2	21.81	20.59	19.86	20.19	20.13	20.43	19.76	21.00	20.09	20.87	19.91	19.87
Flexible	20.31	19.10	19.01	19.14	18.95	18.96	19.22	18.82	19.17	18.25	23.36	20.45
S1-S3	3.02***	2.45**	3.07***	2.74***	3.12***	2.87**	2.98***	2.69**	2.75***	3.50***	-3.53*	1.78
	(1.24)	(1.23)	(0.94)	(1.24)	(1.19)	(1.16)	(0.91)	(1.20)	(0.96)	(1.26)	(1.81)	(1.51)

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

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Table 7: **CAPM Regressions (Benchmark Sample)**

This table reports results for the conditional CAPM. Stocks are assigned to one of five baskets based on the frequency of price adjustment, SAU and returns are equally weighted at the portfolio level. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. α is the intercept and β the slope of times series regressions of monthly portfolio excess returns on a constant and the excess return of the CRSP value weighted index. OLS and Fama and MacBeth (1973) standard errors are reported in parentheses and Newey and West (1987) standard errors in brackets. The conditional CAPM is monthly estimated on a rolling basis over the last twelve months following the methodology of Lewellen and Nagel (2006). The sample period is July 1982 to June 2007.

	Sticky	S2	S3	S4	Flexible	S1-S5
	(1)	(2)	(3)	(4)	(5)	(6)
α_p	0.41	0.35	0.38	0.37	0.40	0.00
SE_{FMB}	(0.05)***	(0.03)***	(0.04)***	(0.04)***	(0.04)***	(0.05)
SE_{NW}	[0.19]**	[0.12]***	[0.14]***	[0.13]***	[0.14]***	[0.14]
β_p	1.29	1.21	1.15	1.08	0.91	0.37
SE_{FMB}	(0.02)***	(0.01)***	(0.01)***	(0.01)***	(0.02)***	(0.02)***
SE_{NW}	[0.05]***	[0.04]***	[0.05]***	[0.04]***	[0.06]***	[0.05]***

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 8: **Cash-Flow and Discount-Rate Betas (Benchmark Sample)**

This table reports results for a beta decomposition into cash-flow β, β_{CF}, and discount-rate β, β_{DR}, following Campbell and Vuolteenaho (2004) as well as their sum. GMM (Hansen (1982)) standard errors conditional on the estimated news series are reported in parentheses. Stocks are assigned to one of five baskets based on the frequency of price adjustment, SAU, and returns are equally weighted at the portfolio level. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. The sample period is from July 1982 to June 2007.

	Sticky	S2	S3	S4	Flexible	S1-S5
	(1)	(2)	(3)	(4)	(5)	(6)
$\beta_{p,CF}$	0.55 * **	0.54 * **	0.51 * **	0.48 * **	0.41 * **	0.14 * **
	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.03)
$\beta_{p,DR}$	0.60 * **	0.57 * **	0.54 * **	0.50 * **	0.44 * **	0.15 * **
	(0.067	(0.06)	(0.06)	(0.06)	(0.07)	(0.03)
β_p	1.15	1.11	1.05	0.98	0.85	0.29

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 9: **Return Sensitivities to Federal Funds Rate Surprises**

This table reports results from regressing monthly percentage excess returns on a constant and the surprise component of the one-month change in the Federal Funds rate and the CAPM predicted response for five portfolios sorted on the frequency of price adjustment and the CRSP value-weighted index (market). Stocks are assigned to one of five baskets based on the frequency of price adjustment, SAU, and returns are equally weighted at the portfolio level. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. OLS standard errors are reported in parentheses and Newey and West (1987) standard errors are in brackets. The sample period is June 1989 to June 2007.

| | Market | Sticky | S2 | S3 | S4 | Flexible | S1-S5 |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\beta_{p,FFR}^{actual}$	-9.35%	-11.42%	-10.19%	-9.35%	-8.85%	-5.01%	-6.41%
	$(2.51){*}{*}{*}$	$(3.01){*}{*}{*}$	$(2.85){*}{*}{*}$	$(2.81){*}{*}{*}$	$(2.66){*}{*}{*}$	$(2.55){*}{*}$	$(1.55){*}{*}{*}$
	$[2.66]{*}{*}{*}$	$[4.12]{*}{*}{*}$	$[3.46]{*}{*}{*}$	$[3.36]{*}{*}{*}$	$[3.37]{*}{*}{*}$	$[2.98]{*}$	$[2.26]{*}{*}{*}$
$\beta_{p,FFR}^{pred}$		-10.88%	-10.65%	-10.02%	-9.38%	-7.45%	-3.41%

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 10: **Long-Horizon Predictability (Benchmark Sample)**

This table reports results for m-month forecasting regressions of the log premium for sticky-price firms on the proxy for the consumption-wealth ratio of Lettau and Ludvigson (2001), cay. Stocks are assigned to one of five baskets based on the frequency of price adjustment, SAU, and returns are equally weighted at the portfolio level. Equally weighted probabilities of price adjustments are calculated at the firm level using the micro data underlying the Producer Price Index constructed by the Bureau of Labor Statistics. For each regression, the table reports OLS standard errors in parentheses, Newey and West (1987) standard errors in brackets, Hansen and Hodrick (1980) standard errors in curly brackets, and Hodrick (1992) standard errors in angle brackets. The sample period is July 1982 to June 2007.

Horizon m (Months)	1	6	12	24	36	48	60
$b_{lh}^{(m)}$	0.24	1.62	3.31	6.32	8.92	10.39	12.39
SE_{OLS}	$(0.08)***$	$(0.18)***$	$(0.22)***$	$(0.34)***$	$(0.45)***$	$(0.64)***$	$(0.69)***$
SE_{NW}	$[0.07]***$	$[0.26]***$	$[0.47]***$	$[1.04]***$	$[1.59]***$	$[1.86]***$	$[1.38]***$
SE_{HH}	$\{0.06\}***$	$\{0.29\}***$	$\{0.53\}***$	$\{1.17\}***$	$\{1.61\}***$	$\{0.76\}***$	$\{0.16\}***$
SE_H	$\langle 0.07 \rangle***$	$\langle 0.42 \rangle***$	$\langle 0.85 \rangle***$	$\langle 1.60 \rangle***$	$\langle 2.50 \rangle***$	$\langle 3.76 \rangle***$	$\langle 3.96 \rangle***$
R^2	3.23%	22.54%	43.58%	55.57%	60.09%	50.95%	57.51%

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 11: **Model-Implied Stock Returns**

This table reports annualized mean excess returns for simulated data of the model of Section IV, the model-implied equity risk premium (ERP), the Sharpe ratio (SR) as well as the sensitivity (β_{SAU}) of annualized returns on the monthly frequency of price adjustment: $R_{jk,t} = \alpha + \beta_{SAU} \times (1 - \theta_k)$. A five-sector version of the model is calibrated using standard parameter values reported in Table A.10 and the empirical distribution of the frequency of price adjustment of Nakamura and Steinsson (2008). The model is solved using a second-order approximation as implemented in dynare, employing the pruning package of Andreasen et al. (2014), calibrated at a quarterly frequency and simulated for 400 firms in each sector for 500 periods discarding the first 250 periods as burn in.

		Sticky	S2	S3	S4	Flexible	S1-S5	ERP	SR	β_{SAU}
(1)	Baseline	7.91	6.84	6.56	5.96	5.51	2.39	6.56	0.39	−2.48***
(2)	$\epsilon_{ck} = 13$	8.70	6.81	6.41	5.68	5.15	3.55	6.55	0.36	−3.41***
(3)	$\epsilon_{ck} = 11$	7.40	6.89	6.70	6.21	5.85	1.55	6.61	0.41	−1.76***
(4)	$\epsilon_c = 10$	8.15	6.86	6.55	5.94	5.50	2.66	6.60	0.39	−2.66***
(5)	$\epsilon_c = 6$	7.71	6.82	6.57	5.98	5.53	2.18	6.52	0.39	−2.33***
(6)	$\epsilon_w = 6$	7.98	7.03	6.72	6.17	5.76	2.22	6.73	0.42	−2.31***
(7)	$\sigma = 1$	8.51	7.07	6.70	6.20	5.82	2.69	6.86	0.43	−2.55***
(8)	Shock std = 0.009	10.21	7.66	7.19	6.40	5.82	4.39	7.46	0.38	−4.05***
(9)	$\phi_{pi} = 1.3$	5.98	5.88	5.76	5.41	5.16	0.82	5.64	0.38	−1.08***
(10)	$\phi_x = 0.5/4$;	7.90	6.84	6.56	5.96	5.51	2.39	6.55	0.39	−2.47***
(11)	MP shocks only	6.81	5.87	5.64	5.03	4.59	2.23	5.59	0.34	−2.37***
(12)	Technol shocks only	1.08	0.97	0.89	0.83	0.81	0.27	0.92	0.47	−0.27***
(13)	$\phi_x = 0.975$	9.19	7.85	7.46	6.80	6.32	2.87	7.52	0.43	−2.90***

$*p < 0.10, **p < 0.05, ***p < 0.01$