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Abstract

We show that after monetary policy announcements, the conditional volatility of stock market returns rises more for firms with stickier prices than for firms with more flexible prices. This differential reaction is economically large as well as strikingly robust to a broad array of checks. These results suggest that menu costs—broadly defined to include physical costs of price adjustment, informational frictions, and so on—are an important factor for nominal price rigidity at the micro level. We also show that our empirical results are qualitatively and, under plausible calibrations, quantitatively consistent with New Keynesian macroeconomic models in which firms have heterogeneous price stickiness. Because our framework is valid for a wide variety of theoretical models and frictions preventing firms from price adjustment, we provide "model-free" evidence that sticky prices are indeed costly for firms.

JEL classification: E12, E31, E44, G12, G14

Keywords: menu costs, sticky prices, asset prices, high frequency identification

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I Introduction

In principle, fixed costs of changing prices can be observed and measured. In practice, such costs take disparate forms in different firms, and we have no data on their magnitude. So the theory can be tested at best indirectly, at worst not at all. Alan Blinder (1991)

Are sticky prices costly? This simple question stirs an unusually heated debate in macroeconomics. Although the consensus that prices at the micro-level are fixed in the short run seems to be growing,[1] why firms have rigid prices is still unclear. A central tenet of New Keynesian macroeconomics is that firms face costs of nominal price adjustment, which can rationalize why firms may forgo an increase in profits by keeping existing prices unchanged after real or nominal shocks. However, the observed price rigidity does not necessarily entail that nominal shocks have real effects or that the inability of firms to adjust prices burdens firms. For example, Head, Liu, Menzio, and Wright (2012) present a theoretical model in which sticky prices arise endogenously even if firms are free to change prices at any time without any cost. This alternative theory has vastly different implications for business cycles and policy. How can one distinguish between these opposing motives for price stickiness?

The key insight of this paper is that in New Keynesian models, sticky prices are costly to firms, whereas in other models, they are not. Although the sources and types of menu costs are likely to vary tremendously across firms, thus making the construction of an integral measure of the cost of sticky prices extremely challenging, looking at market valuations of firms can provide a natural metric to determine whether price stickiness is indeed costly. In this paper, we exploit stock market information to explore these costs and— to the extent that firms equalize costs and benefits of nominal price adjustment— quantify menu costs. The evidence we document is consistent with the New Keynesian interpretation of price stickiness at the micro level.

Specifically, we merge confidential micro-level data underlying the producer price index (PPI) from the Bureau of Labor Statistics (BLS) with stock price data for individual firms from NYSE Trade and Quote (taq), and study how stock returns of firms with different frequencies of price adjustment respond to monetary shocks (identified as changes in futures on the fed funds rates, the main policy instrument of the Fed) in narrow time

[1] Bils and Klenow (2004), Nakamura and Steinsson (2008).

windows around press releases of the Federal Open Market Committee (FOMC). To guide our empirical analyses, we show in a basic New Keynesian model that firms with stickier prices should experience a greater increase in the volatility of returns than firms with more flexible prices after a nominal shock. Intuitively, firms with larger costs of price adjustment tolerate larger departures from the optimal reset price. Thus, the range in which the discounted present value of cash flows can fluctuate is wider. The menu cost in this theoretical exercise is generic and, hence, our framework covers a broad range of models with inflexible prices.

Consistent with this logic, we find that returns for firms with stickier prices exhibit greater volatility after monetary shocks than returns of firms with more flexible prices. The magnitudes of our estimates are broadly in line with the estimates one can obtain from a calibrated New Keynesian model with heterogeneous firms: a hypothetical monetary policy surprise of 25 basis points (bps) leads to an increase in squared returns of 8 percentage points for the firms with the stickiest prices. This sensitivity is reduced by a factor of 3 for firms with the most flexible prices in our sample. Our results are robust to a large battery of specification checks, subsample analyses, placebo tests, and alternative estimation methods.

Our work contributes to a large literature aimed at quantifying the costs of price adjustment. Zbaracki, Ritson, Levy, Dutta, and Bergen (2004) and others measure menu costs directly by keeping records of costs associated with every stage of price adjustments at the firm level (data collection, information processing, meetings, and physical costs). Anderson, Jaimovich, and Simester (2012) have access to wholesale costs and retail price changes of a large retailer. Exploiting the uniform pricing rule employed by this retailer for identification, they show that the absence of menu costs would lead to 18% more price changes. This approach sheds light on the process of adjusting prices, but generalizing these findings is difficult given the heterogeneity of adjustment costs across firms and industries. Our approach is readily applicable to any firm with publicly traded equity, independent of industry, country, or location. A second strand (e.g., Blinder (1991)) elicits information about costs and mechanisms of price adjustment from survey responses of managers. This approach is remarkably useful in documenting reasons for rigid prices, but, given the qualitative nature of survey answers, it cannot provide a magnitude of the costs associated with price adjustment. By contrast, our approach can provide a quantitative estimate of these costs. A third group of papers (e.g., Klenow and Willis (2007), Nakamura and Steinsson (2008)) integrates menu costs into fully-fledged dynamic stochastic general equilibrium (DSGE) models. Menu costs are estimated or calibrated at values that match moments of aggregate (e.g., persistence of inflation) or micro-level (e.g., frequency of price changes) data. This approach is obviously most informative if the underlying model is correctly specified. Given the striking variety of macroeconomic models in the literature and the limited ability to discriminate between models with available data, one may be concerned that the detailed structure of a given DSGE model can produce estimates that are sensitive to auxiliary assumptions necessary to make the model tractable or computable. By contrast, our approach does not have to specify a macroeconomic model, and thus our estimates are robust to alternative assumptions about the structure of the economy.[2]

Our paper is also related to the literature investigating the effect of monetary shocks on asset prices. In a seminal study, Cook and Hahn (1989) use an event-study framework to examine the effects of changes in the federal funds rate on bond rates using a daily event window. They show that changes in the federal funds target rate are associated with changes in interest rates in the same direction, with larger effects at the short end of the yield curve. Bernanke and Kuttner (2005)—also using a daily event window—focus on unexpected changes in the federal funds target rate. They find that an unexpected interest rate cut of 25 basis points leads to an increase in the CRSP value-weighted market index of about 1 percentage point. Gürkaynak, Sack, and Swanson (2005) focus on intraday event windows and find effects of similar magnitudes for the S&P500. Besides the impact on the level of returns, monetary policy surprises also lead to greater stock market volatility. For example, consistent with theoretical models predicting increased trading and volatility after important news announcements (e.g., Harris and Raviv (1993) and Varian (1989)), Bomfim (2003) finds that the conditional volatility of the S&P500 spikes after unexpected FOMC policy movements. Given that monetary policy announcements also appear to move many macroeconomic variables (see, e.g., Faust, Swanson, and Wright (2004b)), these shocks are thus a powerful source of variation in the data.

[2]Other recent contributions to this literature are Goldberg and Hellerstein (2011), Eichenbaum, Jaimovich, and Rebelo (2011), Midrigan (2011), Eichenbaum, Jaimovich, Rebelo, and Smith (2014), Bhattarai and Schoenle (2014), Vavra (2014), and Berger and Vavra (2013). See Klenow and Malin (2010) and Nakamura and Steinsson (2013) for recent reviews of this literature.

Our approach has several limitations. First, we require information on returns with frequent trades to ensure returns can be precisely calculated in narrow event windows. This constraint excludes illiquid stocks with infrequent trading. We focus on the constituents of the S&P500, which are all major US companies with high stock market capitalization.[3] Second, our methodology relies on unanticipated, presumably exogenous shocks that influence the stock market valuation of firms. A simple metric of this influence could be whether a given shock moves the aggregate stock market. Although this constraint may appear innocuous, most macroeconomic announcements other than the Fed's (e.g., the surprise component of announcements of GDP or unemployment figures by the Bureau of Economic Analysis (BEA) and BLS) fail to consistently move the stock market in the United States. Third, our approach is built on "event" analysis and therefore excludes shocks that hit the economy continuously. Forth, we follow the literature and measure a firm's stickiness as the average frequency of price adjustment. While we can rule popular alternative explanations for our findings, we have no exogenous, randomly assigned variation in frequencies and hence cannot exclude that unoberserved heterogeneity accounts for our findings (however, our placebo test does not favor this explanation). Finally, we rely on the efficiency of financial markets.[4]

The rest of the paper is structured as follows. The next section describes how we measure price stickiness at the firm level. Section III lays out a static version of a New Keynesian model with sticky prices and provides guidance for our empirical specification. This section also discusses our high-frequency identification strategy employing nominal

[3]The intraday event window restricts our universe of companies to large firms, because small stocks in the early part of our sample often experienced no trading activity for several hours even around macroeconomic news announcements, contrary to the constituents of the S&P500. Given the high volume of trades for the latter firms, news is quickly incorporated into stock prices. For example, Zebedee, Bentzen, Hansen, and Lunde (2008), among others, show that the effect of monetary policy surprises is incorporated into prices of the S&P500 within minutes. See also Neuhierl et al. (2013) for the reaction to corporate news releases more generally.

[4]Even though the information set stock market participants require may appear large (frequencies of price adjustments, relative prices, etc.), we document in Subsection *E.* of Section IV that the effects for conditional stock return volatility also hold for firm profits. Therefore, sophisticated investors can reasonably identify firms with increased volatility after monetary policy shocks, and trade on this information using option strategies such as straddles. A straddle consists of simultaneously buying a call and a put option on the same stock with the same strike price, time to maturity, and profits from increases in volatility. Analyzing the identity of traders around macroeconomic news announcements is an interesting question: private investors or rational arbitrageurs and institutional investors. Results of Erenburg, Kurov, and Lasser (2006) and Green (2004), as well as the fact that news is incorporated into prices within minutes, indicate the important role of sophisticated traders around macroeconomic news announcements.

shocks from fed funds futures and the construction of our variables and controls. Section IV presents the estimates of the sensitivity of squared returns to nominal shocks as a function of price stickiness. Section V calibrates a dynamic version of a New Keynesian model to test whether our empirical estimates can be rationalized by a reasonably calibrated model. Section VI concludes and discusses further applications of our novel methodology.

II Measuring Price Stickiness

A key ingredient of our analysis is a measure of price stickiness at the firm level. We use the confidential microdata underlying the PPI of the BLS to calculate the frequency of price adjustment for *each* firm in our sample. The PPI measures changes in selling prices from the perspective of producers, as compared to the Consumer Price Index (CPI), which looks at price changes from the consumers' perspective. The PPI tracks prices of all goods-producing industries, such as mining, manufacturing, gas, and electricity, as well as the service sector. The PPI covers about three quarters of the service sector output.

The BLS applies a three-stage procedure to determine the individual goods included in the PPI. In the first step, the BLS compiles a list of all firms filing with the Unemployment Insurance system. This information is then supplemented with additional publicly available data that are of particular importance for the service sector to refine the universe of establishments.

In the second step, individual establishments within the same industry are combined into clusters. This step ensures that prices are collected at the price-forming unit, because several establishments owned by the same company might constitute a profit-maximizing center. Price-forming units are selected for the sample based on the total value of shipments or the number of employees.

After an establishment is chosen and agrees to participate, a probability sampling technique called *disaggregation* is applied. In this final step, the individual goods and services to be included in the PPI are selected. BLS field economists combine individual items and services of a price-forming unit into categories, and assign sampling probabilities proportional to the value of shipments. These categories are then broken down further based on price-determining characteristics until unique items are identified. If identical goods are sold at different prices due to, for example, size and units of shipments, freight type, type of buyer, or color, these characteristics are also selected based on probabilistic sampling.

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."[5] Taxes and fees collected on behalf of federal, state, or local governments are not included. Discounts, promotions, or other forms of rebates and allowances are reflected in PPI prices insofar as they reduce the revenues the producer receives. The same item is priced month after month. The BLS undertakes great efforts to adjust for quality changes and product substitutions so that only true price changes are measured.

Prices are collected via a survey that is emailed or faxed to participating establishments.[6] Nakamura and Steinsson (2008) document that the behavior of measured prices is insensitive to using alternative collection methods. Individual establishments remain in the sample for an average of seven years until a new sample is selected in the industry. This resampling occurs to account for changes in the industry structure and changing product market conditions within the industry.

We calculate the frequency of price adjustment (FPA) as the mean fraction of months with price changes during the sample period of an item. For example, if an observed price path is \$4 for two months and then \$5 for another three months, only one price change occurs during five months and hence the frequency is 1/5.[7] When calculating FPA, we exclude price changes due to sales. We identify sales using the filter employed by Nakamura and Steinsson (2008). Including sales does not affect our results in any material way because, as documented in Nakamura and Steinsson (2008), sales are rare in producer prices.

We aggregate FPA at the establishment level and further aggregate the resulting frequencies at the company level. We perform the first aggregation via internal establishment identifiers of the BLS. To perform the firm-level aggregation, we *manually*

[5]See Chapter 14, BLS Handbook of Methods, available under http://www.bls.gov/opub/hom/.

[6]The online appendix contains a sample survey.

[7]We do not consider the first observation as a price change and do not account for left censoring of price spells. Bhattarai and Schoenle (2014) verify that explicitly accounting for censoring does not change the resulting distribution of probabilities of price adjustments. Our 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 very similar.

check whether establishments with the same or similar names are part of the same company. In addition, we search for names of subsidiaries and name changes due to, for example, mergers, acquisitions, or restructurings occurring during our sample period for all firms in our financial data set.

We discuss the fictitious case of a company, Milkwell, Inc., to illustrate aggregation to the firm level. Assume we observe product prices of items for the establishments Milkwell Advanced Circuit, Milkwell Aerospace, Milkwell Automation and Control, Milkwell Mint, and Generali Enel. In the first step, we calculate the frequency of product price adjustment at the item level and aggregate this measure at the establishment level for all of the above mentioned establishments.[8] We calculate equally-weighted frequencies (baseline) as well as frequencies weighted by values of shipments associated with items/establishments (see appendix), say, for Milkwell Aerospace. We then use publicly available information to check whether the individual establishments are part of the same company. Assume that we find that all of the above-mentioned establishments with "Milkwell" in the establishment name except for Milkwell Mint are part of Milkwell, Inc. Looking at the company structure, we also find that Milkwell has several subsidiaries: Honeymoon, Pears, and Generali Enel. Using this information, we then aggregate the establishment-level frequencies of Milkwell Advanced Circuit, Milkwell Aerospace, Milkwell Automation and Control, and Generali Enel at the company level, again calculating equally-weighted and value of shipment-weighted frequencies.

To reduce adverse effects of sampling errors, we use the full time series to construct FPA.[9] Focusing on large firms that make up the S&P500 further mitigates the potential effects of measurement errors, because these firms have many individual items in the PPI sample. In the online appendix, we provide additional evidence based on sample splits and estimation by instrumental variables to document that measurement errors do not drive our results.

Table 1 reports average frequencies of price adjustments at the firm level in Panel A, degrees of synchronization of price adjustment within firms in Panel B, as well as the

[8]Items in our data set are alpha-numeric codes in a SAS data set, and we cannot identify their specific nature.

[9]We find little variation in FPA over time at the firm level in our sample period. Allowing for time-series variation has little impact on our findings.

number of products and price spells in the PPI micro data per firm in Panels C and D.[10] Statistics are presented both for the total sample and for each industry separately.[11] The overall mean frequency of price adjustment (FPA) is 14.17%/month, implying an average duration, $-1/ln(1 - FPA)$, of 6.54 months. A substantial amount of heterogeneity is present in the frequency across sectors, ranging from as low as 8.47%/month for the service sector (implying a duration of almost one year) to 26.96%/month for agriculture (implying a duration of 3.18 months). Finally, the high standard deviations highlight dramatic 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 because of a different customer and supplier structure, heterogeneous organizational structure, or varying operational efficiencies and management philosophies.[12] The degree of synchronization in price adjustment varies across industries in a fashion similar to the frequency of price adjustment. Panels C and D show that an average firm in our sample has more than 110 unique products and 202 price spells in the micro data to measure the frequency of price adjustment.

III Framework

In this section, we outline the basic intuition for how returns and price stickiness are related in the context of a New Keynesian macroeconomic model. We will focus on one shock—monetary policy surprises—that has a number of desirable properties.[13] Although restricting the universe of shocks to only monetary policy shocks limits our analysis in terms of providing an integral measure of costs of sticky prices, it is likely to improve identification greatly and generate a better understanding of how sticky prices and stock returns are linked. This section also guides us in choosing regression specifications for the

[10] We define synchronization of price adjustment as the share of price quotes of a given firm in a given month that have a price change. For example, if a firm in a given month has five products in the BLS sample and two of the products have a price change, the synchronization rate is 2/5.

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

[12] Nakamura and Steinsson (2008) report a median frequency of price changes for producer prices between 1998 and 2005 of 10.8%, 13.3%, and 98.9% for finished producer goods, intermediate goods, and crude materials, respectively, corresponding to median implied durations of 8.7, 7, and 0.2 months.

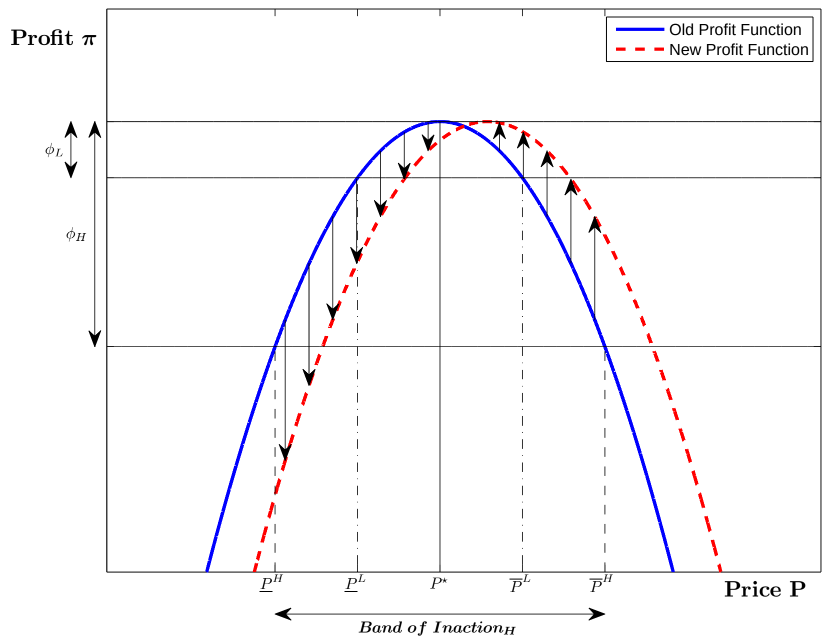
[13] Bernanke and Kuttner (2005) emphasize the importance of financial markets for the conduct of monetary policy: "The most direct and immediate effects of monetary policy actions, such as changes in the Federal funds rate, are on financial markets; by affecting asset prices and returns, policymakers try to modify economic behavior in ways that will help to achieve their ultimate objectives."

empirical part of the paper and describes how we construct variables.

A. Static model

We start with a simple, static model to highlight intuition for our subsequent theoretical and empirical analyses. Suppose that a second-order approximation to a firm's profit function is valid so that the payoff of firm i can be expressed as $\pi_i \equiv \pi(P_i, P^*) = \pi_{max} - \psi(P_i - P^*)^2$, where P^* is the optimal price given economic conditions, P_i is the current price of firm i, π_{max} is the maximum profit a firm can achieve, and ψ captures the curvature of the profit function.[14] The blue, solid line in Figure 1 shows the resulting approximation. Furthermore, assume a firm has to pay a menu cost ϕ if it wants to reset

Figure 1: Impact of a Nominal Shock on Stock Returns via a Shift in Firm's Profit Function



This figure plots profit at the firm level as a function of price. Low and high menu costs (ϕ_L and ϕ_H) translate into small and large bands of inaction within which it is optimal for a firm not to adjust prices following nominal shocks. The blue, solid line indicates the initial profit function and P^* is the initial optimal price. For example, an expansionary monetary policy shock shifts the profit function to the right, indicated by the dashed, red line. Depending on the initial position, this shift can lead either to an increase or a decrease in profits as exemplified by the arrows.

its price. This cost should be interpreted broadly as not only the cost of re-printing a menu with new prices, but also of collecting and processing information, bargaining with suppliers and customers, and so on. A firm resets its price from P_i to P^* only if the gains

[14] This expansion does not have a first-order term in $(P_i - P^*)$, because firm optimization implies that the first derivative is 0 in the neighborhood of P^*.

from doing so exceed the menu cost, that is, if $\psi(P_i - P^*)^2 > \phi$. If the menu cost is low ($\phi = \phi_L$), the range of prices consistent with inaction (non-adjustment of prices) is $(\underline{P}_L, \overline{P}_L)$. If the menu cost is high ($\phi = \phi_H$), the range of price deviations from P^* is wider $(\underline{P}_H, \overline{P}_H)$. As a result, the frequency of price adjustment is ceteris paribus lower for firms with larger menu costs. We denote the frequency of price adjustment with $\lambda \equiv \lambda(\phi)$ with $\partial\lambda/\partial\phi < 0$. We can interpret $1 - \lambda$ as the degree of price stickiness.

Without loss of generality, we can assume that prices of low-menu-cost and high-menu-cost firms are spread in $(\underline{P}_L, \overline{P}_L)$ and $(\underline{P}_H, \overline{P}_H)$ intervals, respectively, because firms are hit with idiosyncratic shocks (e.g., different timing of price adjustments as in Calvo (1983), firm-specific productivity, cost and demand shocks) or aggregate shocks we are not controlling for in our empirical exercise. Suppose there is a nominal shock that moves P^* to the right (denote this new optimal price with P^*_{new}) so that the payoff function is now described by the red, dashed line. This shift can push some firms outside their inaction bands and they will reset their prices to P^*_{new} and thus weakly increase their payoffs, (i.e., $\pi(P^*_{new}, P^*_{new}) - \pi(P_i, P^*_{new}) \geqslant \phi$). If the shock is not too large, many firms will continue to stay inside their inaction bands.

Obviously, this non-adjustment does not mean that firms have the same payoffs after the shock. Firms with negative $(P_i - P^*)$ will clearly lose (i.e., $\pi(P_i, P^*_{new}) - \pi(P_i, P^*) < 0$) as their prices become even more suboptimal. Firms with positive $(P_i - P^*_{new})$ will clearly gain (i.e., $\pi(P_i, P^*_{new}) - \pi(P_i, P^*) > 0$) as their suboptimal prices become closer to optimal. Firms with positive $(P_i - P^*)$ and negative $(P_i - P^*_{new})$ may lose or gain. In short, a nominal shock to P^* redistributes payoffs.

Note that there are losers and winners for both low-menu-cost and high-menu-cost firms. In other words, if we observe an increased payoff, we cannot infer that this increased payoff identifies a low-menu-cost firm. If we had information about $(P_i - P^*_{new})$ and/or $(P_i - P^*)$, that is, *relative* prices of firms, we could infer the size of menu costs directly from price resets. This information is unlikely to be available in a plausible empirical setting, because P^* is hardly observable.

Fortunately, there is an unambiguous prediction with respect to the variance of changes in payoffs in response to shocks. Specifically, firms with high menu costs have larger variability in payoffs than firms with low menu costs. Indeed, high-menu-cost firms can tolerate a loss of up to ϕ_H in profits, whereas low-menu-cost firms take at most a loss of ϕ_L. This observation motivates the following empirical specification:

$$(\Delta\pi_i)^2 = b_1 \times v^2 + b_2 \times v^2 \times \lambda(\phi_i) + b_3 \times \lambda(\phi_i) + error, \tag{1}$$

where $\Delta\pi_i$ is a change in payoffs (return) for firm i, v is a shock to the optimal price P^*, and $error$ absorbs movements due to other shocks. In this specification, we expect $b_1 > 0$ because a shock v results in increased volatility of payoffs. We also expect $b_2 < 0$ because the volatility increases less for firms with smaller bands of inaction and hence with more flexible prices. Furthermore, the volatility of profits should be lower for low-menu-cost firms unconditionally so that $b_3 < 0$. In the polar case of no menu costs, there is no volatility in payoffs after a nominal shock, because firms always make π_{max}.[15]

Although the static model provides intuitive insights about the relationship between payoffs and price stickiness, it is obviously not well-suited for quantitative analyses for several reasons. First, when firms decide whether to adjust their product prices, they compare the cost of price adjustment with the present value of future increases in profits associated with adjusting prices. Empirically, we measure returns that capture both current dividends/profits and changes in the valuation of firms. Because returns are necessarily forward-looking, we have to consider a dynamic model. Second, general equilibrium effects may attenuate or amplify effects of heterogeneity in price stickiness on returns. Indeed, strategic interaction between firms is often emphasized as the key channel of gradual price adjustment in response to aggregate shocks. For example, in the presence of strategic interaction and some firms with sticky prices, even flexible price firms may be reluctant to change their prices by large amounts and thus may appear to have inflexible prices (see, e.g., Haltiwanger and Waldman (1991) and Carvalho (2006)). Finally, the sensitivity of returns to macroeconomic shocks is likely to depend on the cross-sectional distribution of relative prices, which varies over time and may be difficult to characterize analytically.

[15] In a more realistic setting, strategic interaction between firms and market demand externalities can change profits for firms with flexible prices; that is, in response to shocks, the profit function can shift not only left-right, but also up-down. In this case, squared payoffs (or stock market returns) increase even for firms with perfectly flexible prices. In simulations and in the data, we find $b_1 + b_2 \approx 0$, which is consistent with left-right shifts, but it does not mean neutrality of money. The absolute and relative magnitudes of b_1 and b_2 depend on the size of shocks, degree of real rigidity, cross-sectional distribution of relative prices, and many other factors. In this basic model, we abstract from this complexity and focus on left-right shifts in the profit function to keep the intuition transparent. In addition, one can test non-neutrality of money directly using first moments; see Table 3. To be clear, we do *not* make this assumption ($b_1 + b_2 \approx 0$) in either the fully-fledged dynamic version of the model presented in Section V or in our empirical analyses.

To address these concerns and check whether the parameter estimates in our empirical analysis of Section IV are within reasonable ranges, in Section V we calibrate the dynamic multi-sector model developed in Carvalho (2006), where firms are heterogeneous in the degree of price stickiness.

B. Identification

Identification of unanticipated, presumably exogenous shocks to monetary policy is central for our analysis. In standard macroeconomic contexts (e.g., structural vector autoregressions), one may achieve identification by appealing to minimum delay restrictions whereby monetary policy is assumed to be unable to influence the economy (e.g., real GDP or unemployment rate) within a month or a quarter. However, asset prices are likely to respond to changes in monetary policy within days if not hours or minutes (see e.g. Andersen, Bollerslev, Diebold, and Vega (2003), and Rigobon and Sack (2003)).

To address this identification challenge, we employ an event-study approach in the tradition of Cook and Hahn (1989) and more recently Bernanke and Kuttner (2005). Specifically, we examine the behavior of returns and changes in the Fed's policy instrument in narrow time windows around FOMC press releases when the only relevant shock (if any) is likely due to changes in monetary policy. To isolate the unanticipated part of the announced changes of the policy rate, we use federal funds futures, which provide a high-frequency market-based measure of the anticipated path of the fed funds rate.

We calculate the surprise component of the announced change in the federal funds rate as

$$v_t = \frac{D}{D-t}(ff^0_{t+\Delta t^+} - ff^0_{t-\Delta t^-}), \tag{2}$$

where t is the time when the FOMC issues an announcement, $ff^0_{t+\Delta t^+}$ is the fed funds futures rate shortly after t, $ff^0_{t-\Delta t^-}$ is the fed funds futures rate just before t, and D is the number of days in the month.[16] The $D/(D-t)$ term adjusts for the fact that the federal funds futures settle on the average effective overnight federal funds rate.

[16] We implicitly assume in these calculations that the average effective rate within the month is equal to the federal funds target rate and that only one rate change occurs within the month. Due to changes in the policy target on unscheduled meetings, we have six observations with more than one change in a given month. Because these policy moves were not anticipated, they most likely have no major impact on our results. We nevertheless analyze intermeeting policy decisions separately in our empirical analyses. While constructing v_t, we have also implicitly assumed that a potential risk premium does not change in the $[t-\Delta t^-, t+\Delta t^+]$ window, which is consistent with results in Piazzesi and Swanson (2008).

Using this shock series, we apply the following empirical specification to assess whether price stickiness leads to differential responses of stock returns:

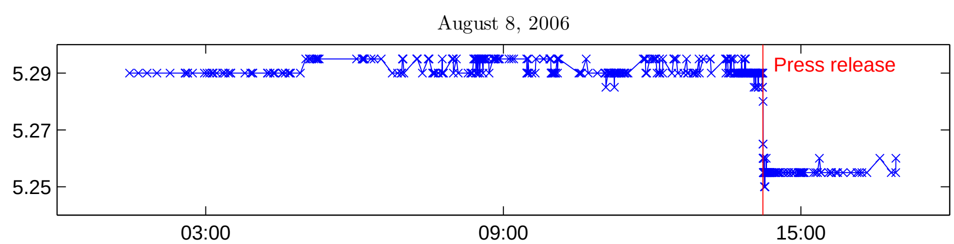
$$R^2_{it} = b_0 + b_1 \times v^2_t + b_2 \times v^2_t \times \lambda_i + b_3 \times \lambda_i + FirmControls + FirmControls \times v^2_t + error, \quad (3)$$

where R^2_{it} is the squared return of stock i in the interval $[t-\Delta t^-, t+\Delta t^+]$ around event t, v^2_t is the squared monetary policy shock, and λ_i is the frequency of price adjustment of firm i. Below, we provide details on how high-frequency shocks and returns are constructed and we briefly discuss properties of the constructed variables. Our identification does not require immediate reaction of inflation to monetary policy shocks but can also operate through changes in current and future demand and costs that are immediately incorporated in returns through changes in the discounted value of profits.[17]

C. Data

We construct v_t using tick-by-tick data of the federal funds futures trading on the Chicago Mercantile Exchange (CME) Globex electronic trading platform (as opposed to the open-outcry market) directly from the CME. To provide an insight into the quality of the data and the adequacy of our high-frequency identification strategy, we plot the futures-based expected federal funds rate for a typical event date in Figure 2. This plot shows two general patterns in the data: high trading activity around FOMC press releases and immediate market reaction following the press release.

Figure 2: Intraday Trading in Globex Federal Funds Futures



This figure plots the tick–by–tick trades in the Globex federal funds futures for the FOMC press release on August 8, 2006, with release time at 2:14pm.

[17]Bernanke and Kuttner (2005) show for a sample period similar to ours that surprises in the federal funds rate on market excess returns operate mainly through their impact on future dividends, highlighting the importance of the cash-flow channel in explaining the effects of monetary policy shocks on *aggregate* stock market returns. Vuolteenaho (2002) shows that stock returns at the *firm* level are mainly driven by cash-flow news, contrary to the findings of Campbell (1991) and Cochrane (1992) for the *aggregate* market.

We consider "tight" and "wide" time windows around the announcement. The tight (wide) window is 30 (60) minutes and starts $\Delta t^{-} = 10$ (15) minutes before the press releases are issued. Panel A of Table 2 reports descriptive statistics for surprises in monetary policy for all 137 event dates between 1994 and 2009, as well as separately for turning points in monetary policy and intermeeting policy decisions.[18] Turning points (target rate changes in the direction opposite to previous changes) signal changes in the current and future stance of monetary policy and thus convey larger news (Jensen, Mercer, and Johnson (1996), Piazzesi (2005), Coibion and Gorodnichenko (2012)).

The average monetary policy shock is approximately 0. The most negative shock is more than -45 bps—about three times larger in absolute value than the most positive shock. Policy surprises on intermeeting event dates and turning points are more volatile than surprises on scheduled meetings. Lastly, the monetary policy shocks are almost perfectly correlated across the two event windows (see Figure 3 in the appendix).[19]

We sample returns for all constituents of the S&P500 for all event dates. We use the CRSP database to obtain the constituent list of the S&P500 for the respective event date and link the CRSP identifier to the ticker of the NYSE taq database (covers NYSE, Amex, and Nasdaq tick-by-tick data) via historical CUSIPs (an alphanumeric code identifying North American securities). We use the last observation before the start of the event window and the first observations after the end of the event window to calculate event returns. For the five event dates for which the press releases were issued before the start of the trading session (all intermeeting releases in the easing cycle starting in 2007; see Table 16 in the appendix), we calculate event returns—0.00,0.00,1.00measured in percentage points—using closing prices of the previous trading day and opening prices of the event day.[20]

Our sample period ranges from February 2, 1994, the first FOMC press release in

[18]Table 16 in the appendix reports event dates, time stamps of the press releases, actual target rates changes, and expected as well as unexpected changes.

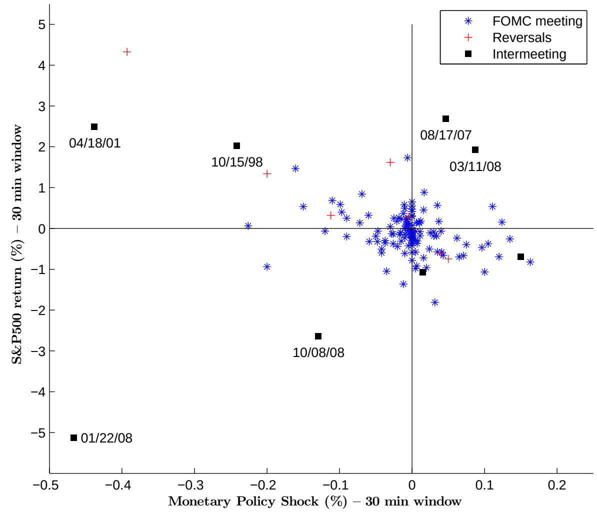
[19]Only two observations have discernible differences: August 17, 2007, and December 16, 2008. The first observation is an intermeeting event day on which the FOMC unexpectedly cut the discount rate by 50 bps at 8:15am ET just before the opening of the open-outcry futures market in Chicago. The financial press reports heavy losses for the August futures contract on that day and a very volatile market environment. The second observation, December 16, 2008, is the day on which the FOMC cut the federal funds rate to a target range between 0% and 0.25%.

[20]Intermeeting policy decisions are special in several respects, as we discuss later. Markets might therefore need additional time to fully incorporate the information contained in the FOMC press release into prices. In a robustness check, we calculate event returns using the first trade after 10:00 am on the event date. Result do not change materially.

1994, to December 16, 2009, the last announcement in 2009, for a total of 137 FOMC meetings. We exclude the rate cut of September 17, 2001—the first trading day after the terrorist attacks of September 11, 2001.[21] Panel B of Table 2 reports descriptive statistics for the percentage returns of the S&P500 for all 137 event dates between 1994 and 2009, turnings points, and intermeeting policy decisions. The average return is close to 0 with an event standard deviation of about 1%. The large absolute values of the tight (30 minute) and wide (60 minute) event returns are remarkable. Looking at the columns for intermeeting press releases and turning points, we see the most extreme observations occur on non-regular release dates. Figure 3, a scatterplot of S&P500 event returns versus monetary policy shocks, highlights this point. Specifically, this figure shows a clear negative relation between monetary policy shocks and stock returns on regular FOMC meetings and on policy reversal dates in line with Bernanke and Kuttner (2005) and Gürkaynak et al. (2005). The scatterplot, however, also documents that anything goes on intermeeting announcement days: negative (positive) monetary policy shocks induce positive and negative stock market reactions with about equal probabilities. Faust, Swanson, and Wright (2004a) argue that intermeeting policy decisions are likely to reflect new information about the state of the economy and hence the stock market reacts to this new information rather than changes in monetary policy. This logic calls for excluding

[21] Our sample starts in 1994, because our tick-by-tick stock price data are not available before 1993 and the FOMC changed the way it communicated its policy decisions. Prior to 1994, the market became aware of changes in the federal funds target rate through the size and the type of open market operations of the New York Fed's trading desk. Moreover, most of the changes in the federal funds target rate took place on non-meeting days. With the first meeting in 1994, the FOMC started to communicate its decision by issuing press releases after every meeting and policy decision. Therefore, the start of our sample eliminates almost all timing ambiguity (besides the nine intermeeting policy decisions). The increased transparency and predictability makes the use of our intraday identification scheme more appealing because our identification assumptions are more likely to hold.

Figure 3: Return of the S&P500 versus Monetary Policy Shocks (tight window)



This figure is a scatterplot of the percentage returns on the S&P500 versus the federal funds futures-based measure of monetary policy shocks calculated according to equation 2 for the tight (30min) event window. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. We distinguish between regular FOMC meetings, turning points in monetary policy, and intermeeting press releases.

intermeeting announcements.[22]

Firms are heterogeneous in many dimensions. Ehrmann and Fratzscher (2004) and Ippolito, Ozdagli, and Perez (2013), among others, show that firms with low cash flows, small firms, firms with low credit ratings, high price-earnings multiples, and Tobin's q show a higher sensitivity to monetary policy shocks, which is in line with bank lending, balance sheet, and interest rate channels of monetary policy. To rule out that this heterogeneity drives our results, we control for an extended set of variables at the firm and industry level. For example, we construct measures of firm size, volatility, cyclical properties of demand, market power, cost structure, financial dependence, access to

[22]Romer and Romer (2000) document that the inflation forecasts of the Fed's staff beat commercial forecasts, which is consistent with the Fed having an informational advantage over professional forecasters, and thus opens a possibility that our measured surprises in the fed funds rate can capture both policy surprises and the Fed's revelation of information about the state of the economy. On the other hand, Coibion and Gorodnichenko (2012) document (see their Table 6) that, at least over the horizons of a few quarters, financial markets are as good at predicting movements in the fed funds rates as the Fed's staff, and hence, quantitatively, the revelation component is probably small. In addition, Faust et al. (2004a) argue that FOMC announcements do not contain superior information about the state of the economy, because professional forecasters do not systematically change their forecasts for a wide range of macroeconomic variables following FOMC press releases, and these forecasts are efficient given the announcement. Finally, although the revelation component can make the mapping of empirical results to a theoretical model less straightforward, it does not invalidate our empirical analysis, because we only need an unanticipated shock that moves optimal reset prices and therefore returns. The nature of this shock is not material.

financial markets, and so on. We use data from a variety of sources, such as the Standard and Poor's Compustat database, publications of the U.S. Census Bureau, and previous studies. The appendix contains detailed information on how we measure these variables.

IV Empirical Results

A. Aggregate Market Volatility

We first document the effects of monetary policy shocks on the return of the aggregate market to ensure these shocks are a meaningful source of variation. Table 3 reports results from regressing returns of the S&P500 on monetary policy surprises, as well as squared index returns on squared policy shocks for our tight event window (30 minute). Column (1) shows that a higher than expected federal funds target rate leads to a drop in stocks prices. This effect—contrary to findings in the previous literature—is not statistically significant. Restricting our sample period to 1994-2004 (or 1994-2007), we can replicate the results of Bernanke and Kuttner (2005), Gürkaynak et al. (2005), and others: a 25 bps unexpected cut in interest rates leads to an increase of the S&P500 by more than 1.3%. In column (3), we find a highly statistically significant impact of squared policy shocks on squared index returns. Conditioning on different types of meetings shows that turning points in monetary are the major driver of the overall effect. Widening the event window mainly adds noise, increasing standard errors and lowering R^2s, but does not qualitatively alter the results.[23] In summary, monetary policy surprises are valid shocks for our analysis.

B. Baseline

Panel A in Table 4 presents results for the baseline specification (3), where we regress squared event returns at the firm level on the squared policy surprise, the frequencies of price adjustments, and their interactions. We cluster standard errors at the event level and report them in parentheses, but statistical inference is similar if we employ Driscoll and Kraay (1998) standard errors, which account for correlation of error terms across time and firms.

Column (1) of Panel A shows that squared surprises have a large positive impact

[23] Appendix Table 2 in the online appendix contains results both for the 30-minute event window in columns (1) to (6) as well as the 60-minute event window in columns (7) to (12).

on squared stocks returns. The point estimate is economically large and statistically significant at the 1% level: a hypothetical policy surprise of 25 bps leads to an increase in squared returns of roughly 8 percentage points (=$0.25^2 \times 128.50$) which corresponds to a return of 2.83 percentage points.[24] The estimated coefficient on the interaction of the frequency of price adjustment and the squared shock indicates that this effect is lower for firms with more flexible prices. For the firms with the most flexible prices in our sample (which have a probability of price adjustment of roughly 0.5 per month), the impact of squared monetary policy shocks is reduced by a factor of 3, that is, $(\beta_1 - 0.5 \times \beta_3)/\beta_1 \approx 1/3$. Importantly, this sensitivity is broadly in line with the estimates we obtain for simulated data from a calibrated New Keynesian model (see Section V).

The differential response of conditional volatility for sticky and flexible price firms is a very robust result. Controlling for outliers (column (2)),[25] adding firm fixed effects (columns (3) and (4)), adding firm and event (time) fixed effects (columns (5) and (6)), or looking at a 60-minute event window (columns (7) and (8)) does not materially change point estimates and statistical significance for the interaction term between squared policy surprises and the frequency of price adjustment. Increasing the observation period to a daily event window (columns (9) and (10)) adds a considerable amount of noise, reducing explanatory power and increasing standard errors. Point estimates are no longer statistically significant, but they remain economically large, and relative magnitudes are effectively unchanged. This pattern is consistent with Bernanke and Kuttner (2005) and Gürkaynak et al. (2005), documenting that for the aggregate market, R^2s are reduced by a factor of 3 and standard errors increase substantially as the event window increases to the daily frequency.[26]

We use only two data ticks in the baseline measurement of stock returns; we find similar results for returns weighted by trade volume in time windows before and after our events (Panel B, columns (1) and (2)). As is conventional in finance, our baseline

[24] We use the square of returns in percent as the dependent variable in our regressions.

[25] We use a standard approach of identifying outliers by jackknife as described in Belsley et al. (1980) and Bollen and Jackman (1990). Our results do not change materially for reasonable variation in the threshold identifying observations as outliers; see Appendix Table 9.

[26] Although additional macro announcements or stock-market-relevant news can explain the effects for the aggregate market, many more stock-price-relevant news can be observed for individual stocks, such as earning announcements, analyst reports, management decisions, and so on, rationalizing the large increase in standard errors. Rigobon and Sack (2004) and Gürkaynak and Wright (2013) also highlight that intraday event windows are more well suited from an econometric point of view, because daily event windows might give rise to biased estimates.

specification uses squared returns and squared policy surprises, but using this measure of volatility can amplify adverse effects of extreme observations. In addition to identifying and excluding outliers and influential observations by jackknife, we also address this potential concern by using a specification with absolute values of returns $|R_{it}|$ and policy shocks $|v_t|$, which gives a lower weight to potential outliers. The results do not change qualitatively when we use absolute returns and policy shocks (columns (3) and (4) of Panel B) instead of squared returns and squared shocks.

One may be concerned that the heterogeneity in volatility across firms is largely driven by market movements or exposure to movements of other risk factors rather than forces specific to the price stickiness of particular firms. To address this concern, we consider squared market-adjusted returns (i.e., $(R_{it} - R_t^{SP})^2$), squared CAPM-adjusted returns (i.e., $(R_{it} - \beta_i R_t^{SP})^2$), and squared Fama-French-adjusted returns ($(R_{it} - \beta_{iFF} R_t^{FF})^2$) where β_i and β_{iFF} are time-series factor loadings of the excess returns of firm i on the market excess returns and the three Fama-French factors. All three adjustments (Panel B: columns (5) and (6), columns (7) and (8), and columns (9) and (10)) take out a lot of common variation, reducing both explanatory power and point estimates somewhat but leaving statistical significance and relative magnitudes unchanged or even increasing them slightly. This reduced but significant sensitivity of market-adjusted returns is consistent with Weber (2015). He documents that β is a function of price stickiness. As a result, the increased volatility of stock returns for firms with stickier prices in response to nominal shocks is partially realized via increased riskiness of these stocks. Because we are interested in the total effect of price stickiness on conditional volatility of stock returns, we continue to use unadjusted returns as the baseline.[27]

The sensitivity of conditional volatility to monetary policy shocks may vary across types of events. For example, Gürkaynak et al. (2005) and others show that monetary policy announcements about changes in the path/direction of future policy are more powerful in moving markets. Panel C of Table 4 contains results for different event types. We restrict our sample in columns (3) and (4) to observations before 2007 to control for the impact of the Great Recession and the zero lower bound. The effect of price flexibility increases both statistically and economically in the restricted sample. In the next two columns, we follow Bernanke and Kuttner (2005) and restrict the sample to only episodes

[27] The online appendix contains additional results for adjusted returns.

in which the FOMC changed the policy interest rate. Although this restriction reduces our sample size by more than 50%, it has no impact on estimated coefficients. Some of the monetary policy shocks are relatively small. To ensure these observations do not drive the large effects of price rigidity, we restrict our sample to events with shocks larger than 0.05 in absolute value in columns (7) and (8). Both for the full and the no-outliers samples, statistical and economic significance remains stable or even slightly increases. When we constrain the sample to turning points in policy, the coefficient on the interaction term between the probability of price adjustment and squared policy shocks increases by a factor of three. The effect of policy shocks is somewhat larger for intermeeting releases, as shown in the last column.

C. Additional controls and analysis of subsamples

Although the simple framework in Section III considers only heterogeneity in menu costs as a source of variation in the frequency of price adjustment, FPA depends on a number of factors that determine benefits and costs of price adjustment, such as the curvature of the profit function and the volatility shocks. In Table 5, we add a wide range of controls to disentangle the effect of price stickiness from potentially confounding firm- and industry-level factors.

In the first column, we repeat the baseline regression, excluding outliers. In the first set of controls, we focus on measures of market power and profitability. For example, in column (2), we include the squared shock interacted with the price cost margin (*pcm*) as an additional regressor. Although firms with larger *pcm* appear to have volatility more sensitive to monetary policy shocks, including *pcm* does not alter our conclusions about the sensitivity across firms with different frequencies of price adjustment. Likewise, controlling directly for market power with industry concentration (the share of sales by the four largest firms, $4F - conc\ ratio$, column (3)) does not change our main result. We also find that our results for b_2 in equation (3) do not alter when we control for the book-to-market ratio (column (4)) or firm size (column (5)).[28]

The differential sensitivity of volatility across sticky- and flexible-price firms may arise from differences in the volatility of demand for sticky- and flexible-price firms. For

[28]Note that the coefficient on the squared policy surprise now turns negative. This coefficient, however, can no longer be as easily interpreted as before in the presence of additional control variables. If we report results evaluating additional controls at their mean level, coefficients are similar in size to our benchmark estimation.

example, all firms could face identical menu costs, but firms that are hit more frequently by idiosyncratic shocks have a higher FPA and hence may be closer to their optimal reset prices, which in turn suggests they could have a lower sensitivity to nominal shocks. To disentangle this potentially confounding effect, we explicitly control for the volatility of sales (standard deviation of sales growth rates, *std sale*,[29] column (6)) and for durability of output (columns (7) and (8)) using the classifications of Gomes, Kogan, and Yogo (2009) and Bils, Klenow, and Malin (2012), respectively. The latter control is important, because demand for durable goods is particularly volatile over the business cycle, and consumers can easily shift the timing of their purchases, thus making price sensitivity especially high. Even with these additional regressors, we find the estimated differential sensitivity of volatility across sticky- and flexible-price firms is largely unchanged.

Some heterogeneity of stickiness in product prices may reflect differences in the stickiness of input prices. For example, labor costs are often found to be relatively inflexible because of rigid wages. When we control for input price stickiness proxied by the share of labor expenses in sales (column 9) and by the frequency of wage adjustment at the industry level from Barattieri, Basu, and Gottschalk (2014) (column 10), we find that firms with a larger share of labor cost have greater sensitivity to monetary policy shocks, but these additional controls do not affect our estimates of how stickiness of product prices influences conditional volatility of returns. In columns (11) to (22), we additionally control for the receivables minus payables-to-sales ratio ($RecPay2Y$) to control for the impact of short-term financing, investment-to-sales ratio ($I2Y$) to control for investment opportunities, the depreciation-to-assets ratio ($D2A$) as a measure of capital intensity, Engel curve slopes ($engel$) to control for differences in income elasticities, the rate of synchronization in price adjustments within a firm ($sync$), the number of products at the firm level ($\#prod$), the S&P long-term issuer rating (Rat), the Kaplan - Zingales index (KZ) to investigate the impact of financial constraints, financial leverage (lev) to take into account its effect on risk and returns, fixed costs to sales ($FC2Y$) because a higher ratio might decrease the flexibility to react to monetary policy shocks, as well as the share of sales abroad to overall sales ($export$) because companies with a larger share might be less responsive to U.S. monetary policy. Overall, none of the controls—either individually

[29]We use the standard deviation of annual sales growth at the quarterly frequency to control for seasonality in sales. Ideally, we would want to have higher frequency data to construct this variable, but publicly available sources only contain sales at the quarterly frequency.

or jointly—attenuates the effect of price stickiness, which is highly statistically and economically significant.[30]

In Table 6, we run our baseline regression at the industry level to further mitigate concerns about omitted factors and control for generally unobserved industry heterogeneity. In this exercise, we have typically many fewer firms, and thus estimates have higher sampling uncertainty. Despite large reductions in sample sizes, for four out of the six industries we find a statistically significant negative coefficient on the interaction term between the frequency of price adjustment and squared monetary policy surprises. For the finance industry, this coefficient is not statistically significant. For the service sector, the estimate for the full sample is positive and significant, but a handful of outliers drive this result. Once these outliers are removed, the point estimate becomes much smaller and statistically insignificantly different from zero. One may be concerned that our results might be driven by sectors sensitive to interest rate movements, such as sectors producing durable goods. In columns (10) and (11), we present results for the sample of firms in sectors producing non-durables as defined by Bils et al. (2012). Estimates for this sample are similar to the baseline, and hence increased conditional volatility of returns for sticky-price firms applies broadly across sectors.[31]

An alternative possibility that could drive our results is a general return sensitivity to monetary policy surprises independent of price stickiness. For example, stocks of some firms may be more volatile because these firms have a larger exposure to interest rate risk, which raises their stock volatility in response to monetary shocks. To rule out this alternative explanation, we add another control: the return sensitivity to monetary policy shocks.[32] Specifically, we first estimate the sensitivity (β_{v_t}) by regressing firm-level event returns on monetary policy shocks in our narrow event window. Then we add the return sensitivity interacted with the squared monetary policy surprise in various specifications as an additional control variable in our baseline regression. Table 7 shows that a higher

[30] To explore whether unobserved selection might bias our point estimates, we follow Oster (2013) and compare points estimates and movement in R^2s between our baseline estimate and the model with the full set of controls. The correction term is equal to -186 and it is precisely estimated. This correction indicates that our point estimates might be conservative.

[31] In addition to using firm or industry fixed effects, we estimated specifications in which we define FPA as deviations from industry means to rule out the concern that industry characteristics orthogonal to costs of price adjustment might be driving parts of the effect of price stickiness on conditional volatility. We found that this alternative approach yields results similar to the baseline.

[32] We thank David Romer for suggesting this test.

squared return sensitivity to monetary policy surprises indeed leads to an increase in event return volatilities, but this additional control has a negligible effect on the interaction term of our measure of price stickiness and squared monetary policy shocks.

Basic New Keynesian theory predicts the sensitivity of conditional volatility should be larger for firms with stickier prices, because these firms can deviate more from optimal prices. To test this prediction, we split the sample into two halves based on firms' frequency of price adjustment, FPA, and estimate specification (3) for each half separately. As theory suggests, the coefficient on the interaction term between price stickiness and policy shock is larger for the set of sticky-price firms (columns (1) and (2) compared to columns (3) and (4) of Table 8). To further explore this prediction, we estimate a specification that is non-linear in the frequency of price adjustment, FPA:

$$\begin{aligned} R_{it}^2 &= b_0 + b_1 \times v_t^2 + b_2 \times v_t^2 \times \lambda_i + b_3 \times v_t^2 \times \lambda_i^2 \\ &\quad + b_4 \times \lambda_i + b_5 \times \lambda_i^2 + error. \end{aligned} \tag{4}$$

Columns (5) and (6) in Table 8 show the point estimates of the slopes are consistent with increased sensitivity of stock returns for firms with the stickiest prices (i.e., b_2 is negative and b_3 is positive), but standard errors are too large to have conclusive results.

Finally, we examine if some parts of the FPA distribution drive the sensitivity of the conditional volatility of stock returns to monetary policy shocks. Specifically, we split firms by quintiles of the frequency of price adjustment and estimate the following regression for each quintile separately:

$$R_{it}^2 = b_0 + b_1 \times v_t^2 + error. \tag{5}$$

Columns (7) through (11) show the estimated sensitivity is largest for firms with the stickiest price, and declines monotonically in the frequency of price adjustment. The estimated sensitivity in the top quintile (most flexible prices) is about half of the estimated sensitivity for the bottom quintile (stickiest prices), which is in line with the decline in the sensitivity we obtain in the baseline, parametric specification (3). Thus, our baseline findings apply broadly across firms with different frequencies of price adjustment.

D. Relative Volatility and Placebo Test

Empirically, we find a large and robust effect of the frequency of price adjustment on the association between monetary policy shocks and conditional volatility of stock returns. The effect survives a series of robustness checks aimed at ruling out alternative explanations and factors determining costs and benefits of price adjustment. Ideally, we would like to identify and exploit a source of exogenous variation in the frequency of price adjustment to reinforce conclusions from these tests. In the lack thereof, we perform two additional economically motivated robustness checks to further examine potentially confounding unobserved firm heterogeneity: one in which price stickiness should matter and one in which we do not expect to find an effect of price stickiness.

The first check is built on the following idea. Suppose that there is some unobserved firm characteristic that makes sticky-price firms have unconditionally higher volatility than flexible-price firms. In this case, we may find a high sensitivity of sticky-price firms simply because these firms tend to have high volatility on average. However, if this phenomenon drives the previously documented effects, we should find no effects of price stickiness once we scale the event volatilities by their unconditional volatilities which summarize the effect of this characteristic. To implement this test, we pick a pseudo event window in the middle of two adjacent event dates t and $t-1$ (date $\tau = t-1/2$) and calculate a pseudo event volatility $(1 + R_{i\tau})^2$ in a 30-minute window bracketing 2:15PM on date τ. We then scale the event volatilities of the following event date with these volatilities, $(1 + R_{it})^2/(1 + R_{i\tau})^2$, and run our baseline regression with $(1 + R_{it})^2/(1 + R_{i\tau})^2$ as the dependent variable.

Column (1) in Panel A of Table 9 shows this explanation cannot account for our result that flexible-price firms have lower conditional volatilities than sticky-price firms. Monetary policy surprises increase event volatility compared to non-event dates. This conditional increase is completely offset for the most flexible firms, with both coefficients being highly statistically significant. Controlling for outliers in column (2), firm fixed effects, event fixed effects, or both in columns (3) to (8) does not change this conclusion.

The second check on whether unobserved heterogeneity can drive our results is to run our baseline regression directly on the pseudo event volatilities $(1 + R_{i\tau})^2$. We perform this test in Panel B of Table 9: all coefficients are economically small, none of them is statistically significant, and once we exclude outliers, the coefficient on the interaction term between the monetary policy surprise and the frequency of price adjustment changes sign.

Both tests confirm our baseline findings and help alleviate concerns that our findings might be spurious. However, what determines heterogeneity in the frequency of price adjustment across similar firms within industries is still an open question, as is the identification of a credible source of exogenous variation in FPA.

E. Fundamentals

The large differential effects of price stickiness on the volatility of returns suggest that firms with inflexible prices should experience an increased volatility of profits relative to firms with flexible prices. Detecting this response in fundamentals may be difficult, because information on firm profits is only available at the quarterly frequency. To match this much lower frequency, we add shocks v_t in a given quarter and treat this sum as the unanticipated shock. Denote this shock with $\tilde{v}_t$. We also construct the following measure of change in profitability between the previous four quarters and quarters running from $t+H$ to $t+H+3$:

$$\Delta\pi_{it,H} = \frac{\frac{1}{4}\sum_{s=t+H}^{t+H+3} OI_{is} - \frac{1}{4}\sum_{s=t-4}^{t-1} OI_{is}}{TA_{it-1}} \times 100, \tag{6}$$

where OI is the quarterly operating income before depreciation, TA is total assets, and H can be interpreted as the horizon of the response. We use four quarters before and after the shock to address seasonality of profits. Using this measure of profitability, we estimate the following modification of our baseline specification:

$$(\Delta\pi_{it,H})^2 = b_0 + b_1 \times \Delta\tilde{v}_t^2 + b_2 \times \tilde{v}_t^2 \times \lambda_i + b_3 \times \lambda_i + error. \tag{7}$$

We find (Panel A, Table 10) that flexible-price firms have a statistically lower volatility in operating income than sticky-price firms ($b_2 < 0$). This effect is increasing up to $H =$ six quarters ahead and then this difference becomes statistically insignificant and gradually converges to zero. Firms with stickier prices (smaller FPA) tend to have larger volatilities of profits.[33]

Although these dynamics of profits are consistent with the logic of New Keynesian models, one may gain further insight into sources of increased volatility of profits by examining how volatility of capital expenditures responds to monetary shocks. Specifically, one may be concerned that firms that adjust prices less frequently, also adjust everything else (e.g., employment, investment) weakly and hence experience increased volatility of profits. Using the same aggregation procedure and normalization as we

[33] Interestingly, the estimate of b_1 is statistically positive only at $H = 0$ and turns statistically negative after $H = 5$.

employed for profits, we utilize Compustat data to calculate investment rates for each firm and then use econometric specification (7) with squared investment rates as the dependent variable to investigate if such concerns are founded.[34] We find (Panel B, Table 10) that, similar to profits, capital expenditures are more volatile for firms with stickier prices in response to monetary shocks. Although we do not have data to study other margins of adjustment, the behavior of capital expenditures is inconsistent with the view that sticky-price firms are also sticky along other margins.

V Dynamic General Equilibrium Model

Our regression results suggest price stickiness is potentially costly for firms. Although we cannot completely rule out potentially confounding factors in the data, we can abstract from these factors in a theoretical model and assess whether the estimated sensitivity of stock return volatility is quantitatively rationalizable when the only source of heterogeneity across firms is the degree of price stickiness. To this end, we use the Calvo (1983) model, the workhorse framework for monetary analyses, and enrich it with heterogeneous frequency of price adjustment as in Carvalho (2006). Models with sufficiently many add-on features interacted with alternative sources of firm heterogeneity may be able to capture the patterns we observe in the data, but a key advantage of our approach is that we use a standard, "barebones" model and thereby impose strong discipline on the exercise. In addition, a model in the spirit of Carvalho (2006) allows simple aggregation of heterogeneous firms and a fast and precise solution for and simulation of non-linear dynamics, which is central for modeling risk and volatility.

In the interest of space, we only verbally discuss the model, and focus on key equations.[35] In this model, a representative household lives forever. The instantaneous utility of the household depends on consumption and labor supply. The intertemporal elasticity of substitution for consumption is σ. Labor supply is firm-specific. For each firm, the elasticity of labor supply is η. The household's discount factor is β. Households have a love for variety and have a CES Dixit-Stiglitz aggregator with the elasticity of substitution θ.

[34] We use capital expenditure data from the quarterly Compustat file (item *capxy*). *capxy* represents year-to-date capital expenditure. We transform the variable so that it represents quarterly capital expenditure.

[35] The appendix contains a more detailed description of the model.

Firms set prices as in Calvo (1983). The economy contains k sectors, with each sector populated by a continuum of firms. Each sector is characterized by a fixed λ_k, the probability of any firm in industry k adjusting its price in a given period.[36] The share of firms in industry k in the total number of firms in the economy is given by the density function $f(k)$. Firms are monopolistic competitors and the elasticity of substitution θ is the same for all firms, both within and across industries. Although this assumption is clearly unrealistic, it greatly simplifies the algebra and keeps the model tractable. The production function for output Y is linear in labor N, which is the only input. The optimization problem of firm j in industry k is then to pick a reset price X_{jkt}:

$$\max \mathbb{E}_t \quad \sum_{s=0}^{\infty} Q_{t,t+s}(1-\lambda_k)^s [X_{jkt}Y_{jkt+s} - W_{jkt+s}N_{jkt+s}], \tag{8}$$

subject to its demand function and production technology, where variables without subscripts k and j indicate aggregate variables, W is wages (taken as given by firms), and Q is the stochastic discount factor. The household's intratemporal elasticity between labor and consumption determines wages. The central bank follows an interest rate rule.

After substituting in optimal reset prices and firm-specific demand and wages, the value of the firm V with price P_{jkt} is given by:

$$V(P_{jkt}) \;=\; \mathbb{E}_t \left\{ Y_t^{\sigma} P_t \left[\Delta_{kt}^{(1)} \left(\frac{P_{jkt}}{P_t} \right)^{1-\theta} - \Delta_{kt}^{(2)} \left(\frac{P_{jkt}}{P_t} \right)^{-\theta(1+1/\eta)} + \Upsilon_{kt}^{(1)} - \Upsilon_{kt}^{(2)} \right] \right\}, \tag{9}$$

where $\Upsilon_{kt}^{(1)}$, $\Delta_{kt}^{(1)}$, $\Upsilon_{kt}^{(2)}$, and $\Delta_{kt}^{(2)}$ follow simple recursions and are not indexed by j, which allows particularly easy solution and simulation of this non-linear model.

We calibrate the model at quarterly frequency using standard parameter values in the literature (Table 11). Ashenfelter, Farber, and Ransom (2010) survey the literature on the elasticity of labor supply firms face. They document that the short-run elasticity is in the 0.1-1.5 range, whereas the long-run elasticity is between 2 and 4. We take the middle of the range of these elasticities and set $\eta = 2$. The elasticity of demand θ is often calibrated at 10 in macroeconomic studies. However, because firms in our model compete not only with firms in the same sector, but also with firms in other sectors, we calibrate $\theta = 7$, which captures the notion that the elasticity of substitution across sectors is likely to be low. Other preference parameters are standard: $\sigma = 2$ and $\beta = 0.99$. Parameters of

[36] The fixed probability of price adjustment should be interpreted as a metaphor that allows particularly fast *non-linear* solutions to multi-sector models with large state spaces as well as easy interpretation of results. We find similar results in the Dotsey et al. (1999) model with state-dependent price adjustment.

the policy reaction function are taken from Taylor (1993) and Coibion and Gorodnichenko (2012). We follow Carvalho (2006) and calibrate the density function $f(k) = 1/5$ and use the empirical distribution of frequencies of price adjustment reported in Nakamura and Steinsson (2008) to calibrate $\{\lambda_k\}_{k=1}^{5}$. Specifically, we sort industries by the degree of price stickiness and construct five synthetic sectors that correspond to the quintiles of price stickiness observed in the data. Each sector covers a fifth of consumer spending. The Calvo rates of price adjustment range from 0.094 to 0.975 per quarter, with the median sector having a Calvo rate of 0.277 (which implies that this sector updates prices approximately once a year).

We solve the model using a third-order approximation as implemented in DYNARE, and simulate the model for 100 firms per sector for 2,000 periods, but discard the first 1,850 periods as burn-in. We then calculate for each firm and each time period the value of the firm $V(P_{jkt})$ and the value of the firm net of dividend $\tilde{V}(P_{jkt}) \equiv V(P_{jkt}) - (P_{jkt}Y_{jkt+s} - W_{jkt+s}N_{jkt+s})$, as well as the implied return $R_{jkt} = V(P_{jkt})/\tilde{V}(P_{jkt-1}) - 1$. Then we estimate the sensitivity of stock return volatility using the specification suggested previously:

$$R_{jkt}^2 = b_0 + b_1 \times v_t^2 + b_2 \times v_t^2 \times \lambda_j + b_3 \times \lambda_j + error. \tag{10}$$

We generate 2,000 histories and report average values of estimated b_1, b_2, and b_3 in Table 11 for the baseline calibration as well as for alternative parametrizations. We find that a large, positive $\hat{b}_1$ and a large, negative $\hat{b}_2$ are robust features of the model, with estimates in the ballpark of our empirical findings in Section IV. Magnitudes of the coefficients are such that $\hat{b}_1 + \hat{b}_2 \approx 0$. The estimates of $\hat{b}_3$ are negative, as predicted, but generally close to zero.

We can also use this model to calculate lost profits due to price stickiness: we compute the median profit $\bar{\pi}_k$ for each firm type k and then use $(\bar{\pi}_k - \bar{\pi}_5)/\bar{\pi}_5$ to assess how an increase in the duration of price spells from $(1/\lambda_5)$ (the sector with practically flexible prices) to $(1/\lambda_k)$ influences profits. We find that going from flexible prices to prices fixed for roughly one year (sector 3) reduces profits by about 25%. Although the only source of firm heterogeneity in the model is the duration of price spells, and thus differences in profits can be attributed to price stickiness, heterogeneous costs and benefits of price adjustment affect the duration of price spells in the data, such that the mapping of lost profits to the size of menu costs is likely to be complex. However, the magnitudes we observe in our simulations appear broadly in line with those observed in the data. For example, Zbaracki et al. (2004) show that a manufacturing firm with an average duration of price spells of one year spends about 20% of its net profit margin on nominal price adjustment.

Obviously, these calculations of menu-cost estimates depend on the model's structural parameters. One may use empirical moments to infer these structural parameters. The answer in this exercise is likely to depend on the details of the model, which can limit the robustness. However, these simulations highlight the relationship between price stickiness and returns, and provide a sense of magnitudes one might expect in a reasonably calibrated New Keynesian model with heterogeneous firms.

VI Concluding Remarks

Are sticky prices costly? We propose a simple framework to address this question, using the conditional volatility of stock market returns after monetary policy announcements. We document that the conditional volatility rises more for firms with stickier prices than for firms with more flexible prices. This differential reaction is economically and statistically large as well as strikingly robust to a broad spectrum of checks. This result suggests that menu costs—broadly defined to include physical costs of price adjustment, informational frictions, and so on—are an important factor for nominal price rigidity at the firm level. Our empirical evidence lends support to the New Keynesian interpretation of the observed nominal price rigidity at the microlevel: sticky prices are costly. Our results are qualitatively and, under plausible calibrations, quantitatively consistent with New Keynesian macroeconomic models in which firms have heterogeneous price stickiness. Our "model-free" evidence suggests sticky prices are indeed costly for firms, which is consistent with the tenets of New Keynesian macroeconomics.

Although our results do not prove that monetary shocks have real effects, they provide important building blocks for researchers and policymakers. First, our findings provide foundations for policy-workhorse macroeconomic models such as Christiano, Eichenbaum, and Evans (2005) in which nominal frictions play a prominent role. Second, increasing trend inflation—a policy that a number of economists suggest for combatting deflationary spirals in the Great Recession—has possibly non-negligible costs in light of our results.

Third, sticky prices are an important ingredient for generating large fiscal multipliers in theoretical models (especially in times of a binding zero lower bound on interest rates; see Christiano, Eichenbaum, and Rebelo (2011)). Finally, Bernanke and Kuttner (2005) emphasize that monetary policy can influence the economy via changes in asset prices, and our results can provide a new perspective on this channel, as well as highlight its distributional aspects.

The high-frequency identification of causal effects of monetary shocks on the volatility of stock returns suggests that connecting stock returns and measures of price stickiness is a fruitful avenue for future research. For example, Weber (2015) studies how firm-level and portfolio returns vary with measured price stickiness, which can provide a simple metric of the size of menu costs and shed new light on the sources of the cross-sectional distribution of returns. Alternatively, one may integrate asset prices into fully fledged DSGE models to obtain structural estimates of menu costs. We anticipate that using information on stock returns in conjunction with firm-level measures of price stickiness can help to discriminate between alternative models explaining the large real effect of monetary policy with moderate degrees of price stickiness and the inertial reaction of inflation, improve our understanding of how to price securities, and further bridge finance and macroeconomics.

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

This table reports average frequencies of price adjustments (Panel A), synchronization of price adjustment within firm (Panel B), the number of products in the producer price index micro data per firm (Panel C), and the number of price spells per firm (Panel D). We define synchronization of price adjustment as the share of price quotes of a given firm in a given month that have a price change. For example, if a firm in a given month has five products in the BLS sample and two of the products have a price change, the synchronization rate is 2/5. Standard deviations are in parentheses, and number of observations are reported at the bottom of the table. Equally-weighted statistics are calculated at the firm level using the microdata underlying the producer price index.

	Total	Agriculture	Manufacturing	Utilities	Trade	Finance	Service
Panel A. Frequency of Price Adjustment							
Mean	14.17%	26.96%	11.57%	19.12%	19.70%	13.14%	8.47%
Std	(13.08%)	(17.91%)	(11.19%)	(13.93%)	(13.50%)	(11.63%)	(8.85%)
Panel B. Synchronization of Price Adjustment							
Mean	14.45%	26.33%	11.60%	20.46%	16.99%	14.03%	9.77%
Std	(10.81%)	(17.34%)	(8.54%)	(11.04%)	(9.24%)	(9.42%)	(7.42%)
Panel C. Number of Products							
Mean	110.59	93.67	113.64	199.34	82.99	72.50	69.25
Median	64.18	40.54	73.64	181.51	42.17	44.96	31.99
Std	(124.54)	(112.81)	(119.56)	(177.70)	(96.78)	(74.72)	(82.10)
Panel D. Number of Price Spells							
Mean	202.91	175.39	171.55	485.96	174.60	138.87	87.85
Std	(349.23)	(212.53)	(316.93)	(565.01)	(190.31)	(244.57)	(128.18)
Nobs	760	52	342	109	45	138	74

Table 2: **Descriptive Statistics For High-Frequency Data**

This table reports descriptive statistics for monetary policy shocks (bps) in Panel A and for the returns of the S&P500 in Panel B separately for all 137 event days between 1994 and 2009, turning points in monetary policy, and intermeeting policy decisions. The policy shock is calculated according to equation (2) as the scaled change in the current month federal funds futures in a 30 minutes (tight) window bracketing the FOMC press releases and a 60 minutes (wide) event window around the release times, respectively. The return of the S&P500 is calculated as weighted average of the constituents' returns in the respective event windows, where the market capitalizations at the end of the previous trading days are used to calculate the weights.

	All Event Days		Turning Points		Intermeeting Releases	
	Tight	Wide	Tight	Wide	Tight	Wide
Panel A. Monetary Policy Shocks						
Mean	−1.60	−1.46	−6.09	−5.68	−12.23	−11.09
Median	0.00	0.00	−1.75	−2.75	−5.73	−5.15
Std	8.94	9.11	17.28	16.40	23.84	25.23
Min	−46.67	−46.30	−39.30	−36.50	−46.67	−46.30
Max	16.30	15.20	16.30	15.20	15.00	15.00
Correlation	0.99		0.99		0.99	
Nobs	137		8		8	
Panel B. S&P500 Returns						
Mean	−0.05%	0.05%	0.71%	0.71%	−0.04%	−0.06%
Median	−0.12%	0.02%	0.30%	0.50%	0.64%	0.42%
Std	0.91%	0.97%	1.73%	1.52%	2.83%	2.90%
Min	−5.12%	−5.12%	−0.81%	−0.78%	−5.12%	−5.12%
Max	4.32%	3.61%	4.32%	3.61%	2.69%	2.69%
Correlation	0.90		0.99		0.99	
Nobs	137		8		8	

Table 3: **Response of the S&P500 to Monetary Policy Shocks**

This table reports the results of regressing returns and squared returns in percent of the S&P500 in an event window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2), v_t, and the squared shocks, v_t^2, for different event types in a 30 minutes window bracketing the FOMC press releases. The return of the S&P500 is calculated as a weighted average of the constituents' return in the respective event window, where the market capitilization at the end of the previous trading day is used to calculate the weights. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Newey-West standard errors are reported in parentheses.

	Returns		Squared Returns			
	All	pre-2005	All	Regular	Turning Point	Intermeeting
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.08	−0.12∗	0.13	0.23∗∗∗	−0.36	2.68
	(0.06)	(0.05)	(0.13)	(0.05)	(0.77)	(1.64)
v_t	−1.66	−5.31∗∗∗				
	(2.93)	(1.41)				
v_t^2			84.38∗∗∗	9.57	116.60∗∗∗	67.15
			(23.18)	(8.67)	(9.68)	(38.79)
R^2	0.03	0.44	0.69	0.02	0.92	0.53
Observations	137	92	137	121	8	8

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

Table 4: **Response of the Constituents of the S&P500 to Monetary Policy Shocks**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in different event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2), v_t^2, the frequency of price adjustment, FPA, as well as their interactions. See specification (3). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses. See text for further details.

Panel A. Baseline

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	128.50***	76.95***	127.50***	77.00***			119.60***	95.38***	245.60**	158.4**
	(29.50)	(15.95)	(29.45)	(15.78)			(38.89)	(24.82)	(119.50)	(73.77)
$FPA \times v_t^2$	−169.80**	−67.26***	−168.00**	−67.82***	−166.60**	−43.96***	−130.40*	−78.08***	−340.10	−178.30
	(82.32)	(5.02)	(80.35)	(4.47)	(81.32)	(5.21)	(77.88)	(27.10)	(233.10)	(123.60)
FPA	0.41	0.09					0.55	0.08	0.11	−2.26
	(0.33)	(0.16)					(0.59)	(0.21)	(2.68)	(2.29)
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.12	0.14	0.15	0.20	0.26	0.03	0.09	0.01	0.00
Observations	57,541	57,441	57,541	57,441	57,541	57,422	57,541	55,022	57,541	57,506

Panel B. Variations

	Volume Weighted		Absolute Returns & Shocks		Market adj		CAPM adj		Fama & French adj	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2 (or $\|v_t\|$)	144.50***	86.42***	6.33***	5.37***	47.76**	25.40***	43.80***	27.71***	38.29***	25.80***
	(43.96)	(16.24)	(1.17)	(1.03)	(18.91)	(8.13)	(11.39)	(6.84)	(7.76)	(4.63)
$FPA \times v_t^2$ $(or \|v_t\|)$	−205.90*	−64.59***	−4.11**	−2.84***	−71.52**	−13.20***	−52.96***	−18.35***	−42.57**	−22.52***
	(119.30)	(22.71)	(1.97)	(0.88)	(32.33)	(1.88)	(18.46)	(5.99)	(20.11)	(4.38)
FPA	0.82	0.45	0.11	0.06*	0.05	−0.12	−0.12	−0.23	−0.24	−0.25
	(0.63)	(0.50)	(0.07)	(0.03)	(0.20)	(0.18)	(0.20)	(0.19)	(0.22)	(0.21)
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.06	0.04	0.21	0.19	0.03	0.03	0.03	0.03	0.02	0.02
Observations	55,065	54,996	57,541	57,426	57,541	57,492	57,541	57,491	57,541	57,497

Panel C. Condition on Event Type

	baseline		pre 2007		change in FFR		| shock | > 0.05		turning point	intermeeting
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	128.50***	76.95***	123.10***	53.81***	133.50***	83.76***	134.50***	90.13***	235.10***	78.25***
	(29.50)	(15.95)	(48.87)	(4.61)	(30.86)	(16.90)	(32.44)	(19.49)	(17.32)	(32.00)
$FPA \times v_t^2$	−169.80**	−67.26***	−245.80***	−77.75***	−178.10**	−64.97***	−185.60**	−77.20***	−512.20***	−99.31**
	(82.32)	(5.02)	(111.50)	(12.44)	(86.90)	(9.42)	(91.46)	(19.98)	(42.76)	(37.64)
FPA	0.41	0.09	0.54*	0.02	1.01*	0.48	2.23	0.90	5.48*	1.66
	(0.33)	(0.16)	(0.39)	(0.09)	(0.64)	(0.35)	(1.43)	(0.76)	(2.98)	(4.81)
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No/Yes	No/Yes
R^2	0.12	0.12	0.11	0.13	0.14	0.13	0.12	0.16	0.15	0.04
Observations	57,541	57,441	45,891	45,775	24,752	24,676	15,580	15,525	3,407	3,300

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

Table 5: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (firm & industry level controls)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2), v_t^2, the frequency of price adjustment, FPA, as well as their interactions. See specification (3). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. pcm is the price cost margin defined as sales minus cost of goods sold over sales, $4F - conc\ ratio$ is the four-firm concentration ratio, bm is the book-to-market ratio, and size is the logarithm of the market capitalization. std sale is the volatility of annual sales growth at the quarterly frequency, nondur, serv, invest, gov and nx follow the durable goods classification of Gomes et al. (2009), dura is the durability measure of Bils et al. (2012), labor share is the share of total staff expenses in sales, FWA is the frequency of wage adjustment of Barattieri et al. (2014), RecPay2Y is receivables minus payables to sales, I2Y is investment to sales and D2A is depreciation and amortization over total assets. engel are the Engel curve slopes of Bils et al. (2012), sync is the degree of synchronization in price adjustment at the firm level, #prod is the number of products in the producer price data, Rat is the S&P long term issuer rating, KZ is the Kaplan-Zingales index, Lev is financial leverage, FC2Y is fixed costs to sales, and export is fraction of foreign sales in total sales. The full sample ranges from February 1994 through December 2009, excluding the release of September 17th 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	77.00***	53.14***	82.75***	38.93	−181.30***	49.16***	80.78***	71.05***	127.10***	115.70***
	(15.78)	(18.21)	(16.95)	(33.69)	(36.06)	(11.73)	(11.23)	(17.71)	(24.47)	(23.59)
$FPA \times v_t^2$	−67.82***	−45.52***	−67.68***	−65.03***	−63.02***	−74.70***	−54.57***	−59.91***	−96.51***	−76.12***
	(4.47)	(7.57)	(7.51)	(4.89)	(5.59)	(7.52)	(11.41)	(8.52)	(32.40)	(10.92)
$v_t^2 \times pcm$		52.18***								
		(19.60)								
$v_t^2 \times 4F - conc\ ratio$			−43.22***							
			(10.97)							
$v_t^2 \times bm$				−2.60						
				(1.90)						
$v_t^2 \times size$					16.04***					
					(2.94)					
$v_t^2 \times std\ sale$						532.50***				
						(75.86)				
$v_t^2 \times nondur$							−33.96***			
							(5.29)			
$v_t^2 \times serv$							−27.78***			
							(3.83)			
$v_t^2 \times invest$							7.34			
							(8.97)			
$v_t^2 \times gov$							29.69***			
							(6.34)			
$v_t^2 \times nx$							−0.93			
							(9.77)			
$v_t^2 \times dura$								11.60***		
								(2.07)		
$v_t^2 \times labor\ share$									−91.70**	
									(45.98)	
$v_t^2 \times FWA$										−255.80
										(203.30)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.15	0.17	0.15	0.15	0.16	0.17	0.25	0.16	0.15	0.20
Observations	57,441	51,929	50,126	57,441	57,443	51,929	42,990	47,422	9,722	47,388

Standard errors in parentheses

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

continued on next page

Table 5: **Continued from Previous Page**

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
v_t^2	76.87***	75.71***	85.62***	19.01	92.35***	85.23***	144.70***	71.74***	102.10***	45.29*	71.51***	−128.60
	(15.75)	(13.58)	(17.68)	(24.45)	(16.59)	(16.07)	(19.29)	(16.92)	(18.05)	(23.47)	(19.60)	(115.00)
$FPA \times v_t^2$	−74.10***	−61.80***	−63.52***	−24.76***	−52.22***	−35.33***	−63.20***	−73.44***	−56.14***	−23.50***	−40.36***	−188.70***
	(6.28)	(5.36)	(4.99)	(5.01)	(4.57)	(12.80)	(7.31)	(7.39)	(10.10)	(3.83)	(9.85)	(38.84)
$v_t^2 \times pcm$												−160.30 **
												(76.24)
$v_t^2 \times 4F - conc\ ratio$												−62.34 **
												(26.21)
$v_t^2 \times bm$												0.01
												(1.61)
$v_t^2 \times size$												33.51***
												(6.18)
$v_t^2 \times std\ sale_a$												1,084.00 **
												(442.50)
$v_t^2 \times nondur$												−39.94 **
												(18.94)
$v_t^2 \times serv$												15.08
												(12.13)
$v_t^2 \times invest$												−14.30 **
												(6.31)
$v_t^2 \times gov$												45.58 **
												(22.20)
$v_t^2 \times nx$												71.53***
												(6.55)
$v_t^2 \times dura$												14.78***
												(4.09)
$v_t^2 \times labor\ share$												
$v_t^2 \times FWA$												−1,813.00***
												(380.10)
$v_t^2 \times RecPay2Y$	−1.72											−30.39
	(1.12)											(38.59)
$v_t^2 \times I2Y$		−15.00										−7.17
		(37.91)										(125.50)
$v_t^2 \times D2A$			−260.30 **									191.30
			(130.90)									(195.90)
$v_t^2 \times engel$				57.18***								−32.49*
				(12.87)								(19.12)
$v_t^2 \times sync$					−49.40							51.98
					(39.35)							(73.44)
$v_t^2 \times \#prod$						−0.10***						−0.05***
						(0.02)						(0.02)
$v_t^2 \times Rat$							−20.89***					−12.91***
							(3.02)					(4.23)
$v_t^2 \times KZ$								5.50*				17.00***
								(3.19)				(2.85)
$v_t^2 \times Lev$									−57.41***			−54.35 **
									(8.25)			(22.89)
$v_t^2 \times FC2Y$										141.50 **		174.50
										(57.74)		(119.30)
$v_t^2 \times export$											0.18	0.00
											(0.26)	(0.26)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.15	0.11	0.11	0.160	0.13	0.16	0.17	0.15	0.16	0.17	0.26	0.36
Observations	55,884	55,566	56,146	47,415	57,319	57,433	53,284	56,351	56,388	56,474	31,689	19,796

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

Table 6: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (within industry)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2), v_t^2 *and the interaction term with the frequency of price adjustment, FPA. Columns (10) and (11) exclude durable goods producers. See specification (3). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.*

	All		Agro	Mnfg	Util	Trade	Finance	Service		excl. Durables	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
v_t^2	127.50***	77.00***	81.73*	71.85***	73.68***	74.38***	86.48***	61.28***	80.15***	106.70***	63.95***
	(29.45)	(15.78)	(45.16)	(12.80)	(20.23)	(17.95)	(20.56)	(13.66)	(15.69)	(18.87)	(15.91)
$FPA \times v_t^2$	−168.00 * *	−67.82***	−106.60*	−35.99 * *	−125.00***	−54.99	−20.11	168.60***	33.97	−112.90 * *	−29.45***
	(80.35)	(4.47)	(59.35)	(14.35)	(16.73)	(35.34)	(23.41)	(51.38)	(71.08)	(48.95)	(5.12)
Correction for outliers	No	Yes	No	No	No	No	No	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
R^2	0.14	0.15	0.18	0.22	0.21	0.25	0.09	0.21	0.18	0.12	0.12
Observations	57,541	57,441	3,629	27,887	7,394	3,839	9,836	4,856	4,815	31,805	31,736

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

Table 7: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (controlling for return sensitivity to monetary policy surprises)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2), v_t^2 *the frequency of price adjustment, FPA, as well as their interactions controlling for the sensitivity of returns to monetary policy shocks,* β_{v_t}*. See specification (3). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.*

	baseline		sq return sens		return sens		abs return sens	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
v_t^2	128.50***	76.95***	93.83***	62.03***	117.10***	70.63***	71.95***	49.89 **
	(29.50)	(15.95)	(22.95)	(19.34)	(27.13)	(19.92)	(26.06)	(23.08)
$FPA \times v_t^2$	−169.80 **	−67.26***	−157.90 **	−62.11***	−160.80 **	−61.02***	−170.70 **	−62.17***
	(82.32)	(5.02)	(72.97)	(10.12)	(69.99)	(5.52)	(81.12)	(7.31)
FPA	0.41	0.09	0.81*	0.28	0.47	0.01	0.61	0.16
	(0.33)	(0.16)	(0.45)	(0.18)	(0.38)	(0.15)	(0.39)	(0.17)
$\beta_{v_t}^2 \times v_t^2$			5.54*	2.71***				
			(2.82)	(0.98)				
$\beta_{v_t} \times v_t^2$					−13.52	−6.42		
					(18.05)	(6.82)		
$\lvert\beta_{v_t}\rvert \times v_t^2$							35.20*	17.21 **
							(18.45)	(6.97)
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.12	0.15	0.14	0.12	0.09	0.14	0.13
Observations	57,541	57,441	57,541	57,433	57,541	57,436	57,541	57,429

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

Table 8: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (non-linear effects of FPA)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2), v_t^2, the frequency of price adjustment, FPA, as well as their interactions for different parts of the distribution of FPA. FPA50 denotes the median of the FPA distribution. Columns (1)-(4) are for specification (3). Columns (5) and (6) estimate a quadratic specification (see specification (4)). Columns (5)-(9) are for specification (5). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	FPA < FPA50		FPA >= FPA50		quadratic specification		Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
v_t^2	161.00***	98.52***	115.30***	84.60***	140.90***	81.67***	145.60***	112.70***	100.90***	93.47***	70.67***
	(53.46)	(14.15)	(25.29)	(17.17)	(35.52)	(15.87)	(42.42)	(30.73)	(22.58)	(25.46)	(18.75)
$FPA \times v_t^2$	−929.00	−524.00***	−117.20***	−93.39***	−392.50	−125.60***					
	(873.60)	(65.27)	(25.64)	(11.04)	(266.00)	(29.00)					
$FPA^2 \times v_t^2$					524.80	121.50					
					(437.80)	(97.41)					
FPA	−1.40	−1.78	0.29	0.00	0.19	−0.15					
	(3.25)	(1.15)	(0.28)	(0.13)	(1.03)	(0.37)					
FPA^2					0.55	0.92					
					(2.00)	(0.96)					
Correction outlier	No	Yes	No	Yes	No	Yes	No	No	No	No	No
R^2	0.11	0.07	0.14	0.13	0.12	0.11	0.09	0.13	0.21	0.15	0.10
Observations	27,222	27,117	30,319	30,192	57,541	57,403	10,098	11,783	11,342	12,729	11,589

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

Table 9: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (relative and pseudo event volatilities)**

This table reports the results of regressing the ratio of squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases over the squared percentage returns in a pseudo event window between adjacent event dates on the federal funds futures based measure of monetary policy surprises calculated according to equation (2), v_t^2 *and the interaction term with the frequency of price adjustment, FPA in Panel A. Panel B regresses squared percentage returns of the constituents of the S&P500 in a 30 minutes pseudo event window between adjacent event dates on the federal funds futures based measure of monetary policy surprises calculated according to equation (2),* v_t^2 *and the interaction term with the frequency of price adjustment, FPA. See specification (3). Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.*

Panel A. Relative Volatilities

	Tight Window		Firm FE		Event FE		Firm & Event FE	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
v_t^2	0.57***	0.32***	0.57***	0.33***				
	(0.08)	(0.05)	(0.07)	(0.05)				
$FPA \times v_t^2$	−1.07***	−0.65***	−1.05***	−0.64***	−1.06***	−0.57***	−1.05***	−0.56***
	(0.19)	(0.17)	(0.17)	(0.17)	(0.19)	(0.18)	(0.18)	(0.18)
FPA	0.00***	0.00***			0.00***	0.00***		
	(0.00)	(0.00)			(0.00)	(0.00)		
Event Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.07	0.02	0.09	0.05	0.12	0.10	0.14	0.12
Observations	53,682	53,547	53,682	53,547	53,682	53,507	53,682	53,507

Panel B. Pseudo Event Volatilities

	Tight Window		Firm FE		Event FE		Firm & Event FE	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
v_t^2	2.26	2.01	2.33	2.04				
	(3.79)	(3.33)	(3.57)	(3.07)				
$FPA \times v_t^2$	5.68	−2.05	5.25	−2.11	5.96	−2.19	5.51	−2.33
	(7.60)	(4.78)	(6.91)	(3.88)	(7.60)	(4.66)	(6.92)	(3.80)
FPA	−0.17***	−0.15***			−0.17***	−0.15***		
	(0.04)	(0.04)			(0.04)	(0.04)		
Event Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.00	0.00	0.06	0.06	0.06	0.07	0.11	0.12
Observations	53,262	53,248	53,262	53,248	53,262	53,247	53,262	53,247

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

Table 10: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (profitability and capex)**

This table reports the results of regressing squared percentage changes in mean quarterly operating income before depreciation (Panel A) and capital expenditure (Panel B) between quarters $t+H$ till $t+H+3$ and $t-4$ till $t-1$ normalized by $t-1$ total assets of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) and accumulated to quarterly frequency, $\tilde{v}_t^2$, the frequency of price adjustment, FPA, as well as their interaction. See specification (7). Equally-weighted frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

Panel A. Profitability

	H = 0	H = 1	H = 2	H = 3	H = 4	H = 5	H = 6	H = 7	H = 8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\tilde{v}_t^2$	2.47*	1.75	−0.03	−2.10	−3.69	−7.98 **	−10.51*	−15.99***	−21.55***
	(1.35)	(1.65)	(1.85)	(2.07)	(2.75)	(3.49)	(5.10)	(5.43)	(6.43)
$FPA \times \tilde{v}_t^2$	−19.68***	−23.98***	−25.62***	−30.91 **	−36.81 **	−35.18 **	−41.58 **	−29.98	−29.68
	(4.87)	(6.88)	(7.01)	(8.90)	(12.59)	(13.34)	(17.65)	(20.69)	(23.82)
FPA	2.10***	2.68***	3.24***	3.78***	4.07***	4.01 **	4.77 **	4.70*	4.88
	(0.26)	(0.39)	(0.56)	(0.73)	(0.87)	(1.00)	(1.39)	(1.58)	(1.91)
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	20,756	20,428	20,117	19,814	19,646	19,449	19,295	18,921	18,475

Panel B. Capex

	H = 0	H = 1	H = 2	H = 3	H = 4	H = 5	H = 6	H = 7	H = 8
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\tilde{v}_t^2$	0.35	0.40	0.73	0.99	0.97	1.41	1.74	2.03	1.56
	(0.53)	(0.82)	(1.00)	(1.20)	(1.27)	(1.48)	(1.81)	(2.14)	(2.29)
$FPA \times \tilde{v}_t^2$	−4.64*	−4.84	−10.06 **	−17.56***	−22.14***	−28.55***	−33.48***	−36.15***	−41.64***
	(2.72)	(3.67)	(4.47)	(4.04)	(4.34)	(4.18)	(3.56)	(5.03)	(6.41)
FPA	1.93***	2.66***	3.29***	3.95***	4.38***	4.73***	5.19***	6.03***	6.96***
	(0.22)	(0.31)	(0.43)	(0.51)	(0.55)	(0.49)	(0.46)	(0.46)	(0.56)
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Observations	23,192	22,982	22,788	22,599	22,414	22,233	22,053	21,879	21,714

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

Table 11: **Multi-sector model**

This table shows in Panel A calibrated parameter values for the dynamic New Keynesian multisector model described in Section V, the sectoral distribution of the frequency of price adjustment in Panel B, and the parameter estimates of equation (10) with simulated data from the model in Panel C.

Panel A. Calibration

Parameter	Value	Source
η	2	Ashenfelter et al. (2010)
σ	2	standard
θ	7	standard
β	0.99	standard
ϕ_π	1.5	Taylor (1993)
ϕ_y	0.5	Taylor (1993)
ρ_{mp}	0.9	Coibion and Gorodnichenko (2012)
$std(v_t)$	0.0043	Coibion et al. (2012)

Panel B. Sectoral Distribution

Sector k	Share	Frequency of Price Adjustment
1	0.2	0.094
2	0.2	0.164
3	0.2	0.277
4	0.2	0.638
5	0.2	0.985

Panel C. Simulation Results

Calibration	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$
baseline	221.5	-256.0	-0.008
$\sigma = 3$	161.2	-177.5	-0.006
$\eta = 1$	433.5	-513.8	-0.014
$\theta = 6$	114.0	-120.7	-0.004
$\phi_\pi = 2$	108.0	-127.5	-0.004
$\phi_y = 0.75$	245.7	-287.9	-0.009
$\rho_{mp} = 0.91$	410.5	-494.7	-0.015
$std(v_t) = 0.004$	197.7	-226.2	-0.006

Online Appendix: Are Sticky Prices Costly? Evidence From The Stock Market

Yuriy Gorodnichenko and Michael Weber.

Not for Publication

We include in this appendix a number of details and robustness checks that are omitted in the main text for brevity.

I Firm and Industry Level Controls

In this section we detail our data sources and define the control variables.

Balance sheet data are obtained from the Standard and Poor's Compustat database. We define book equity (BE) as total shareholders' equity plus deferred taxes and investment tax credit (Compustat item TXDITCQ) minus the book value of preferred stock (Compustat item PSTKQ). We prefer the shareholders' equity numbers as reported by Compustat (Compustat item SEQQ). In case this data are not available, we calculate shareholders' equity as sum of common and preferred equity (Compustat items CEQQ and PSTKQ). If neither of the two are available, we define shareholders' equity as the differences of total assets and total liabilities (Compustat items ATQ and LTQ).

The book to market (BM) ratio of event t is then the log of the ratio of book equity for the fiscal quarter ending at least three months before the event date over the market capitalization of the previous trading day. Market capitalization is number of shares outstanding times the closing price (CRSP items SHROUT and PRC). $Size$ is the natural logarithm of the market capitalization as of the previous trading day.

We define labor share ($labor\ share$) as total staff expenses (Compustat item XLR) over net sales (Compustat item SALE). Staff expense data are only sparely available on Compustat. Price to cost margin (PCM) is the ratio of net sales minus costs of goods sold (Compustat item COGS) to net sales. $std\ sale$ is the volatility of annual growth in net sales on a quarterly basis. Fixed costs to sales ($FC2Y$) is defined as the sum of selling, general and administrative expenditures (Compustat item XSGA), advertising (Compustat item XAD) and research and development expenses (Compustat item XRD) over net sales. Receivables minus payables to sales ($RecPay2Y$) is total receivables minus total trade payables (Compustat items RECT and AP) over net sales, investment to sales ($I2Y$) is capital expenditures (Compustat item CAPX) to net sales, and depreciation to assets ($D2A$) is depreciation and amortization (Compustat item DP) over total assets (Compustat item AT). These variables are all averaged across our sample period.

Profitability is operating income before depreciation (Compustat item OIBDPQ) over lagged total assets where both variables are measured on a quarterly basis. Rating (Rat) is the S&P domestic long term issuer credit rating (Compustat item SPLTICRM). We assign the highest rating category, AAA, a value of 4.33, decreasing by 1/8 with every rating notch. We use mean ratings within the year and lag them by 1 year.

We also include the Kaplan - Zingales index (KZ, Kaplan and Zingales (1997)) to control for the impact of financial constraints. This index is defined as:

$$KZ_{it} = -1.002\frac{CF_{it}}{AT_{it-1}} - 39.368\frac{Div_{it}}{AT_{it-1}} - 1.315\frac{C_{it}}{AT_{it-1}} + 3.139Lev_{it} + 0.283Q_{it}, \qquad (1)$$

where cash flow (CF) is the sum of income before extraordinary items (Compustat item IB) and depreciation and amortization, dividends (Div) are measured as common and preferred dividends (Compustat items DVC and DVP), C is cash and short term investments (Compustat item CHE), leverage (Lev) is the ratio of long term debt and debt in current liabilities (Compustat items DLTT and DLC) to stockholders' equity (Compustat item SEQ), long term debt and debt in current liabilities and Q is the ratio of total assets, the market value of equity from CRSP as of fiscal year end, minus the bookvalue of equity and deferred taxes (Compustat items CEQ and TXDB) to total assets. The first three variables are normalized by lagged total assets. We winsorize all variables at the 1% level before calculating the index and use one-year lagged values of the index in our regressions.

Four- and eight-firm concentration ratios ($4F - conc\ ratio$ and $8F - conc\ ratio$) are the means of the concentration ratios at the industry level over the years 1997, 2002, and 2007 as reported by the Census Bureau. We assign firms into categories of final demand based on their durability of output using the industry classification of Gomes, Kogan, and Yogo (2009). They use the 1987 benchmark input-output accounts to assign industries to the classes of final demand to which they have the highest value added: personal consumption expenditure on non-durable goods ($nondur$), durable goods (dur)

and services (*serv*), gross private domestic investment (*invest*), government expenditure and gross investment (*gov*), as well as net export of goods and services (*nx*).

Engel curve slopes (*engel*) and a different measure of durability of output (*dura*, in years) at the industry level are from Bils, Klenow, and Malin (2012). They estimate Engel curve slopes using the micro data underlying the U.S. Consumer Expenditure Surveys Interview Surveys, pooling cross sections from 1982 to 2010. They employ life expectancy tables from a property casualty insurer and estimates from the U.S. Bureau of Economic Analysis to measure durability of output at the industry level.

The frequency of wage adjustment (FWA) at the industry level is from Barattieri, Basu, and Gottschalk (2014). They measure the frequency of nominal wage adjustment using SIPP data adjusted for measurement error.

export is the ratio of sales from foreign operations (export plus FDI) from the Compustat segments file to total sales.

In a robustness test, we use CAPM as well as Fama and French adjusted returns as left-hand-side variables. We calculate factor loadings as full sample time series coefficients of monthly excess returns on the factors. We construct Fama and French factor returns for our 30 minutes event window as in Fama and French (1993) using our sample of firms.

II Dynamic General Equilibrium Model

This section discusses our calibrated mutli-sector New Keynesian model in greater detail. For more information, we refer directly to Carvalho (2006). In this model, a representative household lives forever. The instantaneous utility of the household depends on consumption and labor supply. The intertemporal elasticity of substitution for consumption is σ. Labor supply is firm-specific. For each firm, the elasticity of labor supply is η. The household's discount factor is β. Households have a love for variety and have a CES Dixit-Stiglitz aggregator with the elasticity of substitution θ.

Firms set prices as in Calvo (1983). There are k sectors in the economy with each sector populated by a continuum of firms. Each sector is characterized by a fixed λ_k, the probability of any firm in industry k to adjust its price in a given period. The share of firms in industry k in the total number of firms in the economy is given by the density function $f(k)$. Firms are monopolistic competitors and the elasticity of substitution θ is the same for all firms both within and across industries. While this assumption is clearly unrealistic, it greatly simplifies the algebra and keeps the model tractable. The production function for output Y is linear in labor N which is the only input. The optimization problem of firm j in industry k is then to pick a reset price X_{jkt}:

$$\begin{aligned}
\max \mathbb{E}_t & \quad \sum_{s=0}^{\infty} Q_{t,t+s}(1-\lambda_k)^s[X_{jkt}Y_{jkt+s} - W_{jkt+s}N_{jkt+s}] & (2)\\
s.t.\ Y_{jkt+s} &= N_{jkt+s} & (3)\\
Y_{jkt+s} &= Y_{t+s}\left(\frac{X_{jkt}}{P_{t+s}}\right)^{-\theta} & (4)\\
Q_{t,t+s} &= \beta^s\left(\frac{Y_{t+s}}{Y_t}\right)^{-\sigma} & (5)
\end{aligned}$$

where variables without subscripts k and j indicate aggregate variables, W is wages (taken as given by firms) and Q is the stochastic discount factor. Wages paid by firms are determined by the household's optimization problem:

$$\frac{W_{jkt}}{P_t} = \frac{N_{jkt}^{1/\eta}}{C_t^{-\sigma}}. \tag{6}$$

The aggregate price level and output are given by:

$$\begin{aligned}
P_t &= \left(\int_0^1 f(k)P_{kt}^{(1-\theta)}dk\right)^{1/(1-\theta)}, P_{kt} = \left(\int_0^1 P_{jkt}^{(1-\theta)}dj\right)^{1/(1-\theta)}, & (7)\\
Y_t &= \left(\int_0^1 f(k)^{1/\theta}Y_{kt}^{(\theta-1)/\theta}dk\right)^{\theta/(\theta-1)}, Y_{kt} = f(k)\left(\int_0^1 Y_{jkt}^{(\theta-1)/\theta}dj\right)^{\theta/(\theta-1)}. & (8)
\end{aligned}$$

The central bank follows an interest rate rule:

$$\begin{aligned}
i_t &= \left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi}\left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_y}\beta^{-1}\exp(mp_t) & (9)\\
mp_t &= \rho_{mp}mp_{t-1} + v_t & (10)
\end{aligned}$$

where $exp(i_t)$ is the nominal interest rate, ϕ_π and ϕ_y measure responses to inflation and output growth, and v_t is an i.i.d. zero-mean policy innovation.

After substituting in optimal reset prices and firm-specific demand and wages, the value of the firm V with price P_{jkt} is given by:

$$
\begin{aligned}
V(P_{jkt}) &= \mathbb{E}_t\left\{Y_t^{\sigma}P_t\left[\Delta_{kt}^{(1)}\left(\frac{P_{jkt}}{P_t}\right)^{1-\theta} - \Delta_{kt}^{(2)}\left(\frac{P_{jkt}}{P_t}\right)^{-\theta(1+1/\eta)} + \Upsilon_{kt}^{(1)} - \Upsilon_{kt}^{(2)}\right]\right\} && (11)\\
\Upsilon_{kt}^{(1)} &= \lambda_k\beta\left(\frac{X_{k,t+1}}{P_{t+1}}\right)^{1-\theta}\Delta_{kt+1}^{(1)} + \beta\Upsilon_{kt+1}^{(1)} && (12)\\
\Delta_{kt}^{(1)} &= Y_t^{1-\sigma} + \beta(1-\lambda_k)\left(\frac{P_{t+1}}{P_t}\right)^{\theta-1}\Delta_{kt+1}^{(1)} && (13)\\
\Upsilon_{kt}^{(2)} &= \lambda_k\beta\left(\frac{X_{k,t+1}}{P_{t+1}}\right)^{-\theta(1+1/\eta)}\Delta_{kt+1}^{(2)} + \beta\Upsilon_{kt+1}^{(2)} && (14)\\
\Delta_{kt}^{(2)} &= Y_t^{1+1/\eta} + \beta(1-\lambda_k)\left(\frac{P_{t+1}}{P_t}\right)^{\theta(1+1/\eta)}\Delta_{kt+1}^{(2)}. && (15)
\end{aligned}
$$

III Additional Results

As discussed in the main body of the paper, we calculate the frequency of price adjustment as the mean fraction of months with price changes during the sample period of an item. Because the collected data may have missing values, we construct different measures for the frequency of price adjustment, FP. In the first approach, labeled A, we treat missing values as interrupting price spells. For example, if a price was \$4 for two months, then misses for a month, and is again observed at \$5 for another three months, we treat the data as reporting two price spells with durations of two and three months where none of the spells have a price change and hence the frequency is zero. In the second approach, labeled B, missing values do not interrupt price histories. In the previous example, approach B concatenates spells of \$4 and \$5 prices and yields one price change in five months so that the frequency is 1/5. Approach C takes the union of A and B, that is, there is a price change if either A or B identifies a price change. We employ approach FPA in the main paper, weighting item based frequencies equally. Results are very similar if we make use of these alternative measures.

Figure 1 plots the futures-based expected federal funds rate for additional event dates.

On August 8, 2006, the FOMC decided to stop increasing the federal funds target rate. Until then, the FOMC had been increasing the policy target for more than two years for a total of seventeen increases of 25 bps. This had been the longest streak of increases since the change in market communication in 1994. The FOMC had clearly signalled a pause in previous press releases and according to the financial press around the event, the market also expected this break. Still, the federal funds futures indicate that market participants saw a small chance – potentially due to statements of Jeffrey Lacker, then-President of the Federal Reserve Bank of Richmond, who was opposing the pause – of a further increase resulting in a negative monetary policy surprise of 4.77 bps. This episode shows that policy surprises do not necessarily require changes in the policy rate.

On September 18, 2007, the FOMC cut the target rate by 50 bps, the first cut since 2003. Market participants expected a monetary policy easing. Motivated by weakening economic growth and turmoil in the subprime housing sector, the FOMC considered this step necessary to prevent a credit crunch. The aggressiveness of this decision, though, seemed to surprise the market, resulting in an unexpected change in the federal funds rate of about 20 bps.

On March 18, 2009, the FOMC took further measures in its attempts to ease the uproar on Wall Street after the fall of Bear Stearns. According to Fed watchers, estimates were ranging from a 50 to 125 bps rate cut. On average, market participants expected a cut by 85 bps. The actual cut of 75 bps hence led to a positive surprise of 10 bps. This example shows that surprises in the federal funds rate and changes in the federal funds rate do not necessarily go into the same direction.

Figure 2 shows the observed level of policy inertia and interest rate smoothing.

Figure 3 is a scatterplot of monetary policy shocks in the tight event window on the x-axis and the wide event window on the y-axis. Almost all 137 observations line up perfectly along the 45°line. August 17, 2007, and December 16, 2008, are the only two exceptions. The first observation is an intermeeting event day on which the FOMC unexpectedly cut the discount rate by 50 bps at 8.15am ET just before the opening of the open-outcry futures market in Chicago. The financial press reported heavy losses for the August futures contract on that day and a very volatile market environment. The second observation, December 16, 2008, is the day on which the FOMC cut the federal funds rate to a target range between 0 and 0.25 percent. Table 1 reports mean probabilities, standard deviations, and the number of firm-event observations for these different measures of the frequency of price adjustment, both for the total sample and for each industry separately. Results are very similar across the various measures.

Table 2 documents the effects of monetary policy shocks on the return of the S&P500 to ensure that these shocks are a meaningful source of variation.

Tables 3 – 7 repeat the analyses of Table 4 Panel A in the main body of the text for different measures of price stickiness. Results are comparable across our different measures.

In Table 8, we replicate Table 5 for Fama-French-adjusted returns. While adjusted returns capture only a part of the effect of sticky prices on conditional volatility, we still find a negative coefficient on the interaction term between the frequency of price adjustment on conditional stock volatility across specifications. Coefficients are smaller in magnitude compared to Table 5, but relative magnitudes are comparable.

In Table 9, we show that our results are robust to using different thresholds for the exclusion of outliers. In our baseline specification, we exclude all observations which move the point estimate of the sensitivity (the coefficient on the interaction term $v_t^2 \times FPA$) by more than 0.10 $\times$ standard error of the estimate. The table shows that the coefficient on the interaction term is similar, but somewhat larger (in absolute terms) when we impose a more stringent threshold, i.e. when we exclude more outliers.

In Table 10, we document that the coefficient on the interaction term remains stable and highly statistically significant when we exclude one industry at a time.

We show in Table 11 that our non-parametric results are not driven by industry-level differences in the frequency of price adjustment (FPA). Indeed, we know from Table 1 of the main paper that there is substantial heterogeneity in FPA within industry. In the first version of the non-parametric sort (columns (1) - (5)), we sort firms on industry-adjusted frequencies; that is, we subtract the industry average FPA from a firms' FPA and then sort firms on demeaned FPA. In the second version of the non-parametric sort, we first sort firms in quintiles within industries and then pool quintiles across industries (columns (6)-(10)); that is, the first quintile of the pooled data is the first quintile of industry A, the first quintile of industry B, etc. Sensitivities to squared shocks range from 130.7 for quintile 1 to 74.04 for quintile 5 for the first version of the sort and from 136.0 for quintile 1 to 69.18 for quintile 5 for the second version of the sort. These magnitudes are similar to what we report in the baseline table.

IV Additional descriptive statistics

Since we focus only on large S&P500 firms and hence our sample may be different from samples studied in previous work, we provide additional information about key moments in the data (subject to confidentiality constraints). Figure 4 plots the histogram of the frequency of price adjustment. There is significant heterogeneity. The distribution has substantial mass at low frequencies, but also a large right tail.

Figures 5 and 6 plot the histogram of the absolute size of log price changes with and without sales. Since sales are rare in the PPI data, the plots are similar. While there are many small price changes, the mean size of absolute price changes is about 9% when sales are included and 11% when sales are included. The distribution also has a heavy right tail, which is consistent with previous studies (see e.g. Midrigan (2011)) showing that the distribution of price changes is leptokurtic.

Figure 7 is a histogram of the number of products per firm in the PPI micro data. The mean number of products per firm is 110, but there is a lot of heterogeneity. Some firms have more than 400 products. This large number of products reflects the fact that S&P500 firms are large, and since BLS samples prices based on firm size (a higher sampling probability is assigned to larger firms/establishments), we have considerable presence of units of these firms in the PPI sample.

Figure 8 is a histogram of the degree of synchronization of price adjustment at the firm level. The amount of variation is similar to that for the frequency of price adjustment. The plot also shows that, in general, price changes are not perfectly synchronized within firms/establishments.

Table 15 contains descriptive statistics of the various firm characteristics and explanatory variables used in our regression analysis in Panel A and pairwise correlations in Panel B. Focusing on the correlations of the frequency of price adjustment, FPA, with the various variables, we see that more flexible price firms tend to have lower price-to-cost margins, lower betas, lower labor shares, and lower Engel curve slopes, but have higher book to market ratios, are more financially constrained according to the Kaplan - Zingales index, and have higher investment ratios and higher capital intensities. As for durability, we see that our two classifications lead to correlations with opposite signs. We should point out, however, that none of these correlations is larger than 0.3 in absolute value.

Table 16 contains dates and exact times stamps of the FOMC press releases, actual changes in the federal funds target rates and a decomposition of the actual changes into the expected and unexpected parts as described in the main paper.

V Measurement errors

While we have many observations per firm to calculate the frequency of price adjustment at the firm level, we want to explore how measurement errors can affect our results.

As a first pass, we split the original PPI sample into two subsamples of approximately equal sizes. For a given product/establishment level, we randomly draw (without replacement) a price spell and assign it to one of the subsamples. Then for each subsample, we apply our procedure to calculate the frequency of price adjustment. Given that BLS rotates and randomly samples products and establishments, one can expect that sampling errors in the two subsamples are not correlated. However, the size of sampling errors in the FPA calculated on a subsample is larger, since for each subsample we use only a half of the data. We find that FPA is highly correlated between samples ($\rho = 0.82$).

In columns (3) through (6) in Table 12, we estimate our baseline specification using the frequency of price adjustment constructed from the two subsamples. Because of larger sampling errors in FPA based on subsamples, the sensitivity of stock market volatility to monetary shocks is attenuated to 0. Such attenuation is consistent with classical measurement errors.

If errors are not correlated across subsamples, then one can correct the attenuation bias by using instrumental variable (IV) estimation. Specifically, one can use FPA from one subsample as an instrumental variable for FPA from the other subsample. Columns (7) through (10) present results for IV estimation. The estimated coefficients are close to what we report in the baseline where we use the full sample to calculate FPA. These results suggest that measurement errors are unlikely to drive our results.

In Table 13, we provide additional results to support this conclusion. We split firms based on the number of products into two halves. One may expect that firms with a larger number of products have smaller measurement errors and thus one can obtain less noisy measures of FPA. However, there are potentially confounding factors in this sample split. As documented by Bhattarai and Schoenle (2014) and others, larger firms tend to have more frequent price changes. Indeed, we find that the frequency of price changes is positively correlated with the number of products at the firm level ($\rho = 0.2$). We document in the paper that the effect of price stickiness is likely nonlinear and the sensitivity should be smaller for firms with more flexible prices. Hence, there are two opposing forces: reducing measurement errors should increase the estimated sensitivity to monetary shocks, while increasing price flexibility should reduce it. Table 13 shows that the second force weakly dominates the first. These results suggest that even for firms with many products where measurement errors in FPA are likely to be small, we observe the same qualitative relationship between stock return volatility, monetary shocks, and price stickiness. In Table 14, we show that our results are not driven by the tails of FPA distribution in which measurement error could be more concentrated.

Finally, we use our dynamic model from Section V of the main body of the paper to study how measurement errors affect estimated sensitivity. We consider two cases. First, measurement errors are classical and we model these as $FPA_i = FPA_i^* + me_i$ where FPA is measured frequency of price adjustment, FPA_i^* is the true frequency of price adjustment, me_i is the measurement error with $\rho(FPA_i^*, me_i) = 0$. We vary the size of the measurement error and for each size estimate specification (3) in the paper on the simulated data. Figure 9 plots how estimated sensitivity varies with changes in the signal-to-noise ratio. In short, larger measurement errors attenuate estimated sensitivities toward 0. Therefore, if measurement errors are classical, our estimates provide a lower bound on the sensitivity.

Second, measurement errors are mean-reverting and we model these as $FPA_i = FPA_i^* + me_i$ where FPA is measured frequency of price adjustment, FPA_i^* is the true frequency of price adjustment, me_i is the measurement error, but now $\rho(FPA_i^*, me_i)$ can be different from 0 and we vary the degree of correlation. Holding the signal-to-noise ratio fixed at one, Figure 10 shows that a positive correlation tends to attenuate estimates while a negative correlation tends to amplify estimates. However, it takes a very strong negative correlation to have significant movements in the estimated sensitivity and even in the worst case such correlation cannot alter the orders of magnitude and the signs of the estimated sensitivity

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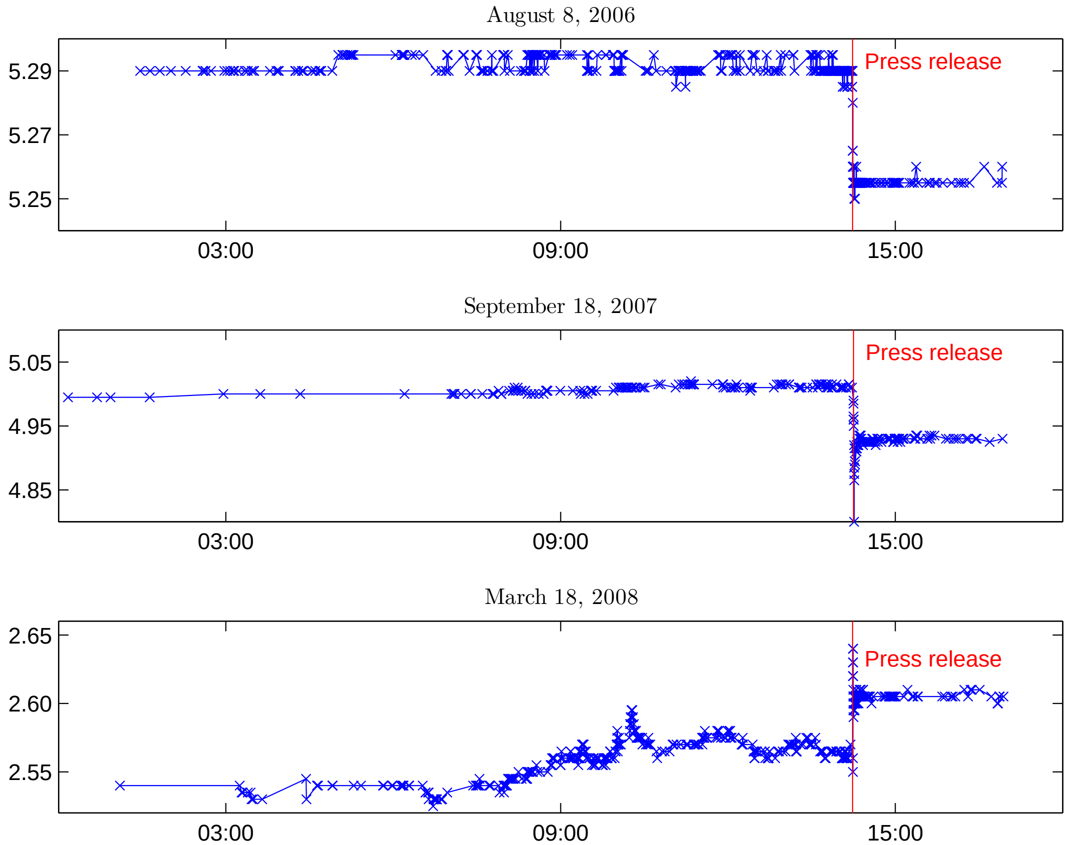
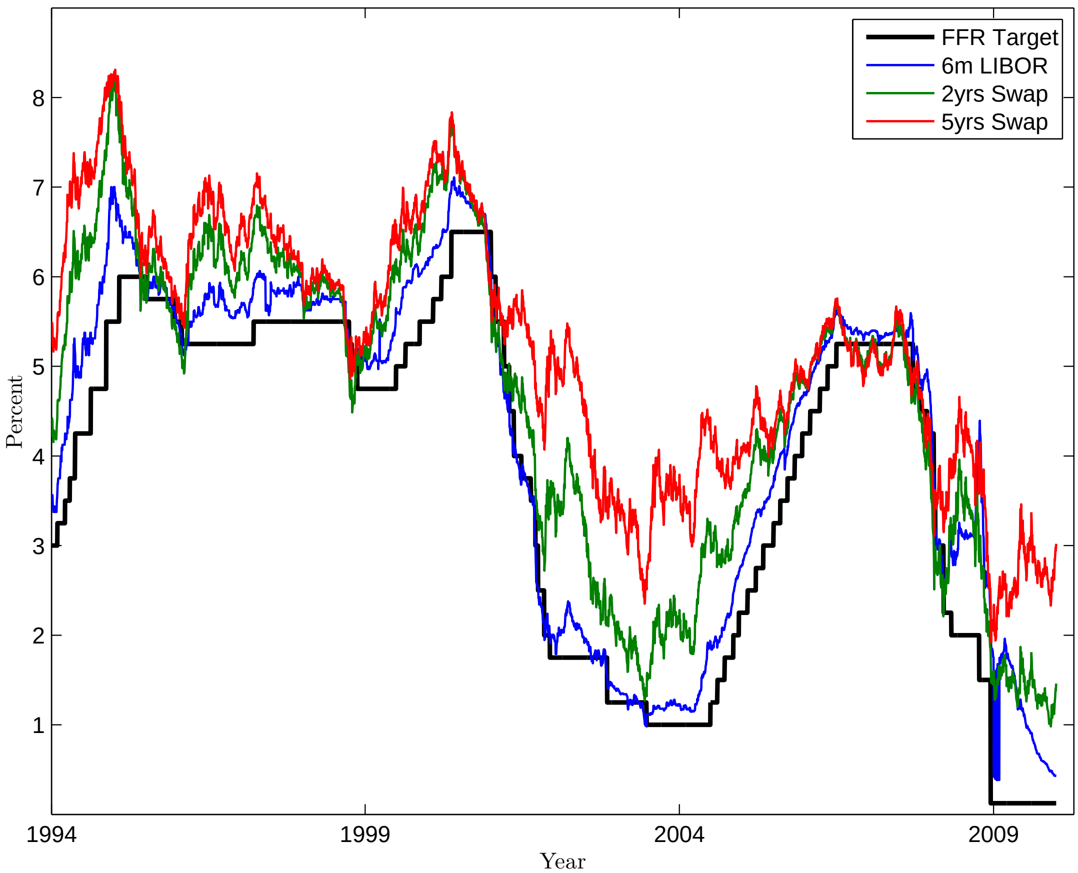
Figure 1: **Intraday Trading in Globex Federal Funds Futures**



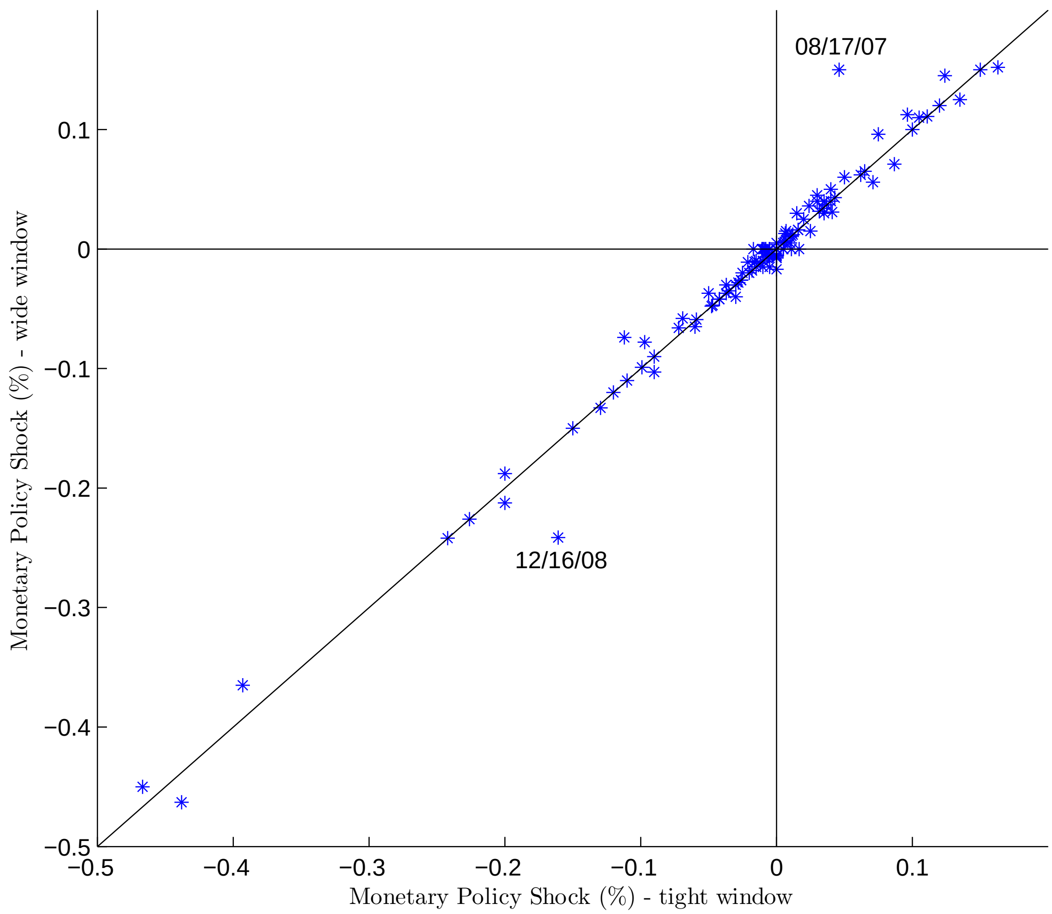
This figure plots the tick–by–tick trades in the Globex Federal funds futures for three different FOMC press release dates with release times at 2:14pm on August 8th 2006, 2:15pm on September 18th 2007 and 2:14pm on March 18th 2008, respectively.

Figure 2: **Time Series of Interest Rates**



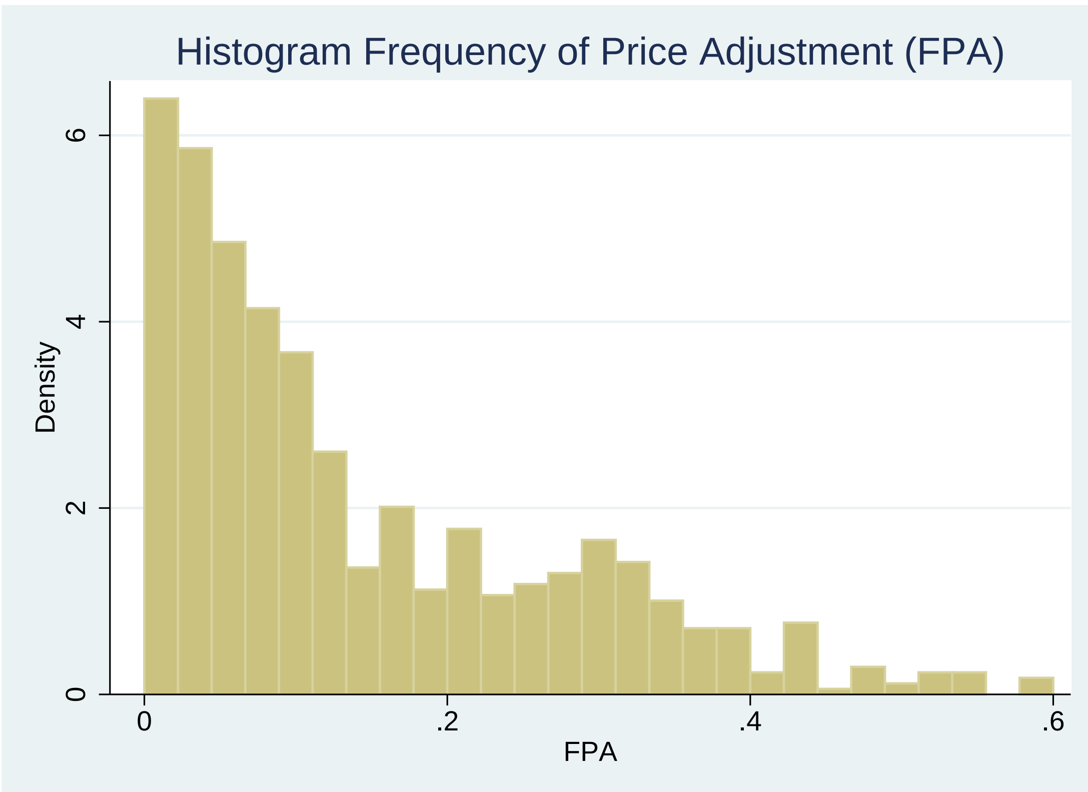
This figure plots the time–series of the federal funds target rate, the six months Libor as well as the two and five year swap rates from 1994 to 2009.

Figure 3: **Futures–based Measure of Monetary Policy Shocks**



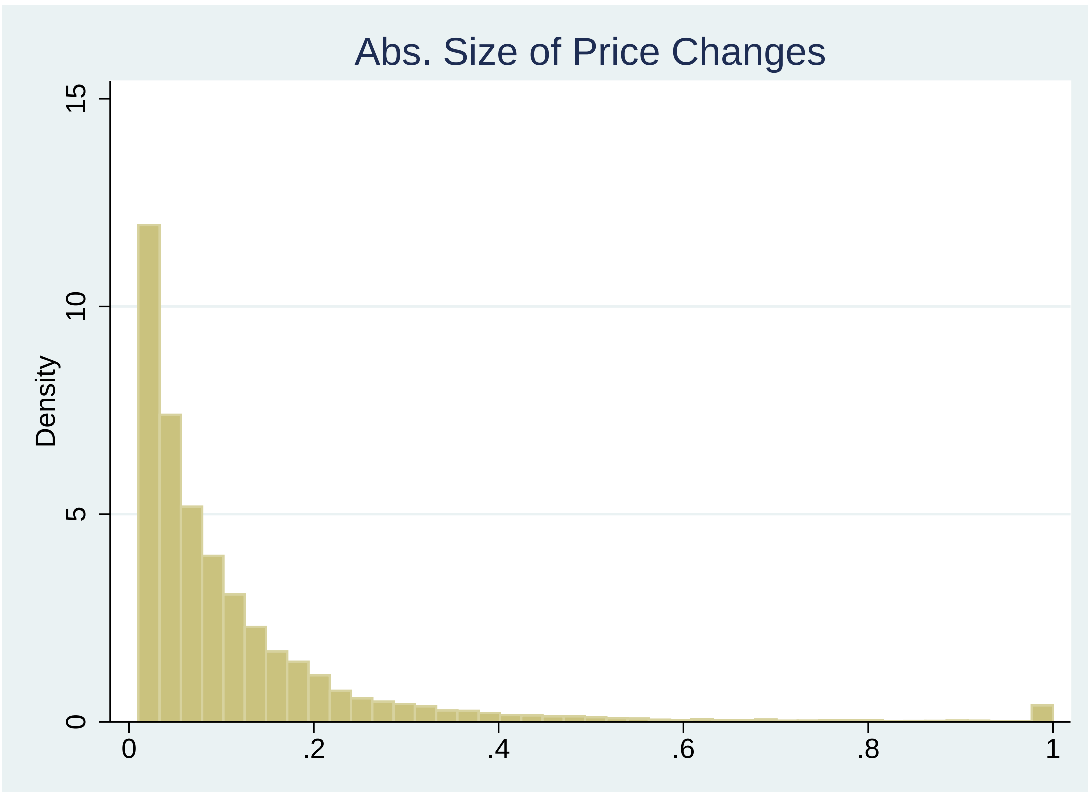
This figure is a scatterplot of the federal funds futures based measure of monetary policy shocks calculated according to equation (2) in the main body of the paper for the wide (60min) event window versus the tight (30min) event window. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations.

Figure 4: **Histogram Frequency of Price Adjustment**



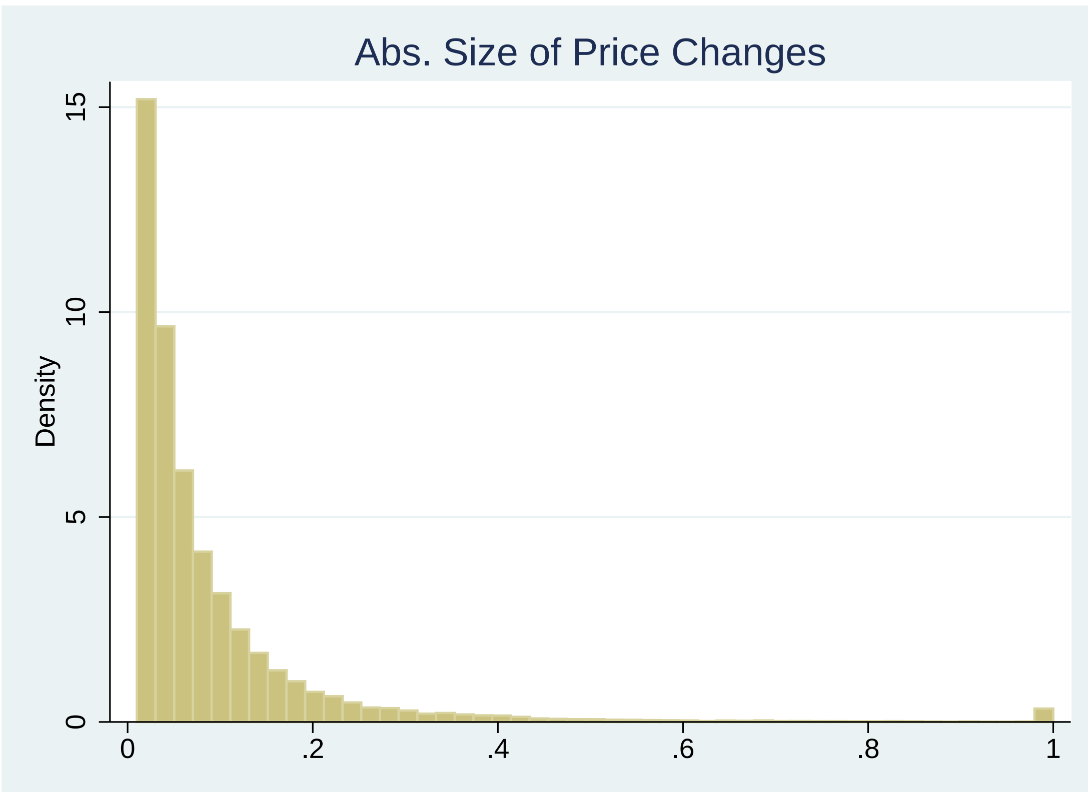
This figure plots the histogram of the frequency of price adjustment.

Figure 5: **Histogram for Absolute Price Changes**



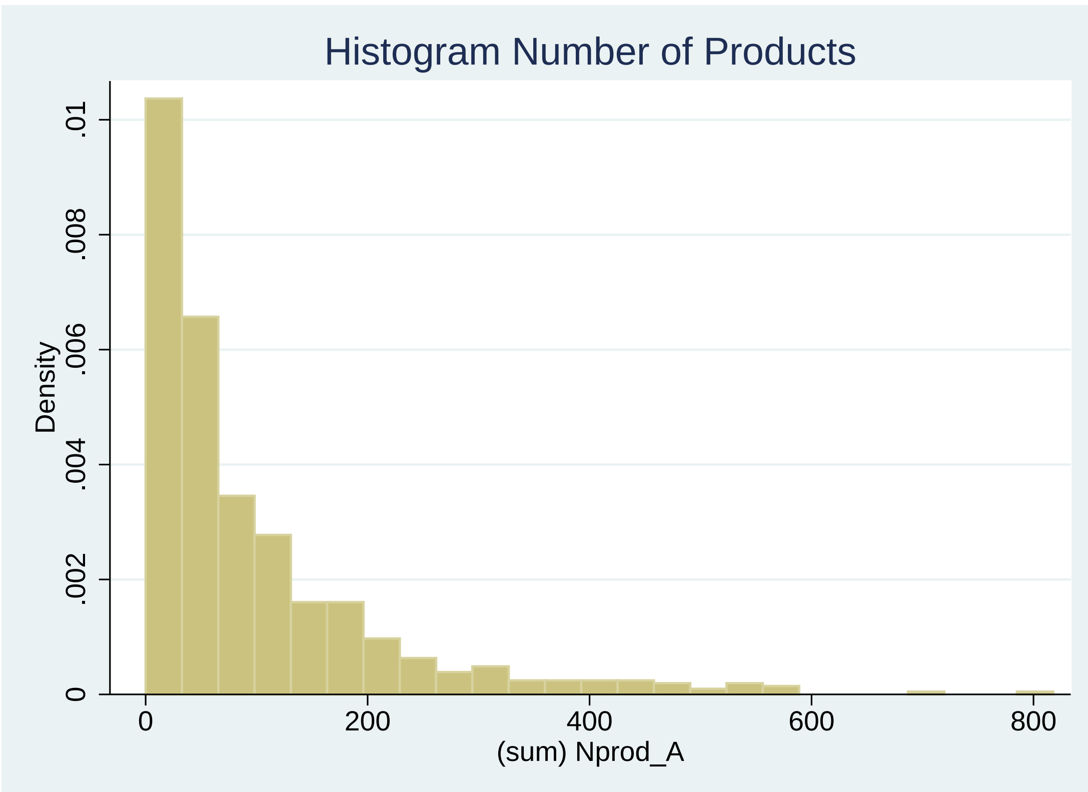
This figure plots the histogram of absolute price changes.

Figure 6: **Histogram for Absolute Price Changes (no sales)**



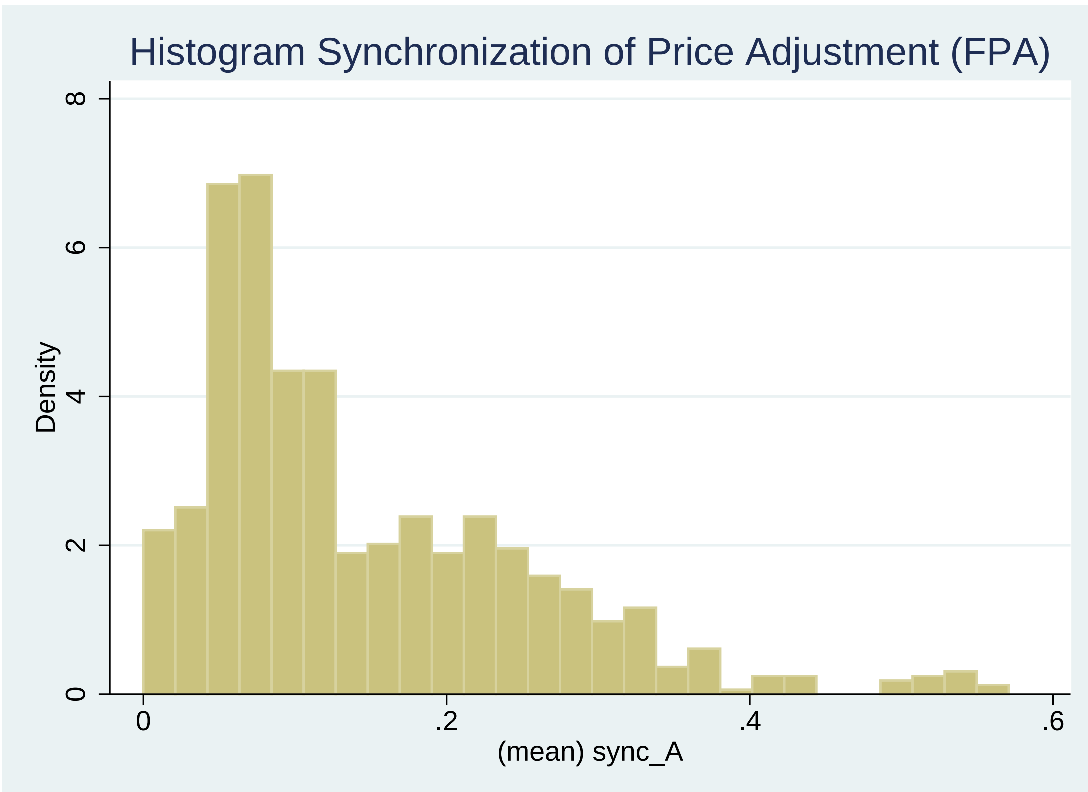
This figure plots the histogram of absolute regular price changes.

Figure 7: **Histogram for Number of Products**



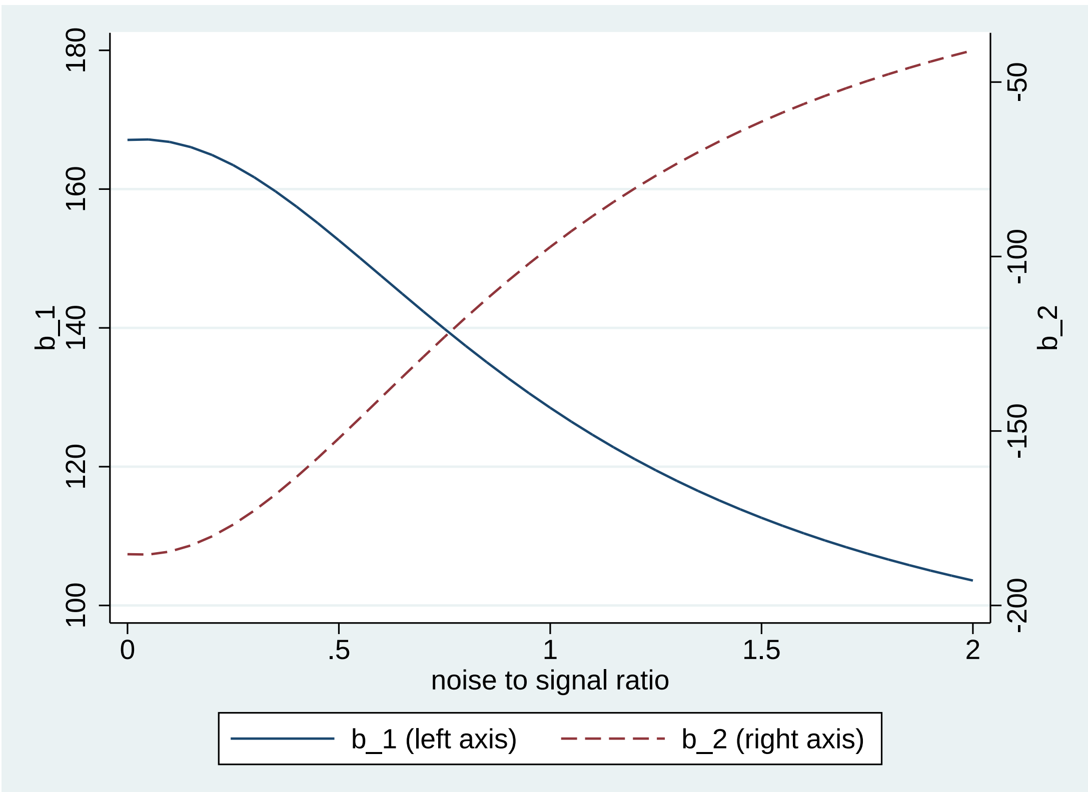
This figure plots the histogram of the number of products.

Figure 8: **Histogram Synchronization of Price Adjustment**



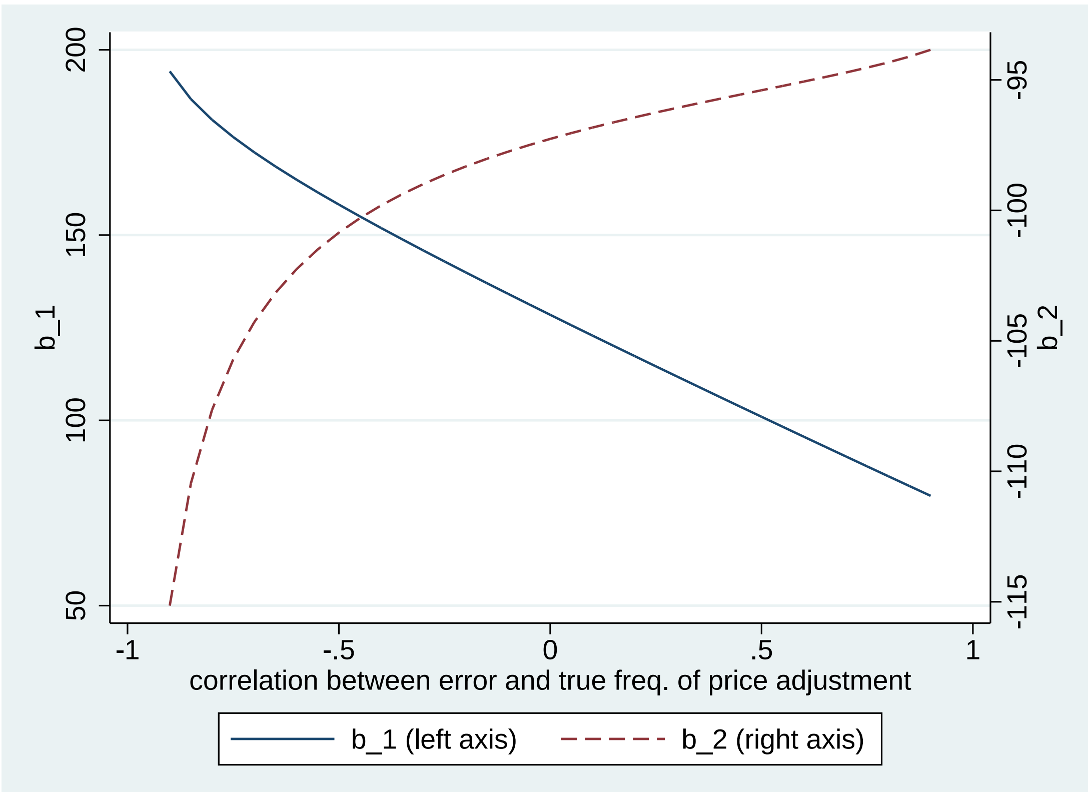
This figure plots the histogram of synchronization of price adjustment. We define price synchronization as the ratio of the number of price changes to the number of price quotes by firm and month.

Figure 9: **Effect of classical measurement error on the estimates of b_1 and b_2 in specification (3)**



This figure shows how estimated sensitivities vary with the size of classical measurement error in simulated data.

Figure 10: **Effect of mean-reverting measurement error on the estimates of b_1 and b_2 in specification (3)**



This figure shows how estimated sensitivities vary with the size of mean-reverting measurement error in simulated data. Mean-reverting measurement errors are modeled as follows: $FPA_i = FPA_i^* + me_i$ *where* $\rho(FPA_i^*, me_i) = \rho \neq 0$. *The signal-to-noise ratio is held constant at 1.*

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This report is authorized by law 29 U.S.C. §2. Your voluntary cooperation is needed to make the results of this survey comprehensive, accurate, and timely.

Form Approved
O.M.B. No. 1220-0008

Public reporting burden for this collection of information is estimated to vary from 1 to 30 minutes per response with an average of 18 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. If you have any comments regarding this estimate or any other aspect of this information collection, including suggestions for reducing this burden, please send them to the Bureau of Labor Statistics, Producer Price Index Program, 1220-0008, Room 3840, 2 Massachusetts Avenue N.E., Washington, DC 20212. You are not required to respond to this collection of information unless it displays a currently valid OMB control number.

DO NOT SENT THE COMPLETED FORM TO THE OFFICE SHOWN ABOVE.

Dear Respondent,

Thank you for your continuing participation in the Producer Price Index (PPI) program. The data that you provide are used in computing the Producer Price Indexes and constitute the basis for analyzing industrial price changes.

Your continued cooperation is greatly appreciated.

Commissioner of Labor Statistics

Instructions for completing a PPI pricing form:

Item/Service and Transaction Descriptions:

If the Item/Service Description or the Terms of Transaction, or both, no long apply, please select a substitute item/service or transaction terms. Item/service substitution should only occur when the item/service previously reported is no longer available because it is being or has been permanently discontinued. The substitute item/service should be as similar as possible to the current item/service and should be expected to remain available for some time. The substitute transaction terms should likewise be as similar as possible to the discontinued transaction terms.

Report these changes in the closest open area and provide current price information.

Adjustments to Price:

Following is a list of the more common adjustments to price. The specific Adjustments to Price on the pricing form were selected originally and should be changed only when either the level of an existing adjustment changes or a new adjustment becomes applicable to the item/service and transaction described.

Deductions from price include:

1. Standard discounts (Cash, Seasonal, Cumulative Volume, and Trade)
2. Rebates
3. Other recurring discounts
4. Other nonrecurring discounts (Competitive and Negotiated)

Additions to price include:

1. Surcharges
2. Other changes added to price

Taxes should always be excluded from the price. If the excusion is not possible, note this in REMARKS.

Freight changes should be excluded from the price unless delivery was selected originally as part of the product. Make changes if the currently described freight terms no longer exist.

QUESTIONS:

Answer whether charges have (YES) or have not (NO) been made to the Item/Service Description, Terms of Transaction, Adjustments to Price, or Previously Reported Prices.

Answer YES or NO depending on whether the shipment/transaction price of the item/service described changed (YES) between the two dates listed or whether the shipment/transaction price did not change (NO) during the time period. If the answer is NO, the form has been completed and is ready for faxing/mailing.

DO NOT ENTER A PRICE IF THE PRICE HAS NOT CHANGED!

If the answer is YES, please also enter the new price.

Write in any corrections to the terms or the address to whom this form should be sent in the future. Name and address changes need to be made on only one form.

Please complete and return within 5 business days all of the pricing forms even if there are no changes.

If you anticipate a change in any of the information you provide, please indicate in REMARKS. List the anticipated changes and when they will occur.

Any questions you have regarding the pricing form or its completion may be resolved by calling the person listed on the reverse side of this form.

INFORMATION FOR THE PRODUCER PRICE INDEXES

Have the Item/Service Description, Adjustments to Price, Terms of Transaction, or Previously Reported Prices changed since your last report? YES ☐ NO ☐
If 'YES', please also enter the necessary changes.

INSTRUCTIONS

THIS FORM IS MACHINE PROCESSED. Limitations imposed by Bureau processing equipment restrict recognition of blue entries. Please use BLACK pen/pencil only.

This item/service has been selected for use in the Producer Price Index. You are asked to provide a price each month for the item/service described under the terms and adjustments shown.

Please review each section of this form. If your firm no longer sells this specific item/service under the terms and adjustments revise the description, terms, and/or adjustments indicating when the changes were made.

If the change made to the description resulted in a change to your production costs, please provide an estimated value of the change for Bureau staff to use in making appropriate adjustments. This value is the production cost difference including your standard markup.

Further instructions are shown on the reverse side of this form. If you have any questions concerning completion of this form, please call collect:

202-691-XXXX

Please use the enclosed postage-free envelope or send to: U.S. Department of Labor
Commissioner of Labor Statistics
2 Massachusetts Avenue N.E., Code 47
Washington D.C. 20212-0001

ITEM DESCRIPTION

TERMS OF TRANSACTION

TYPE OF SALE:
DOMESTIC/FOREIGN BUYER:
TYPE OF BUYER:
SHIPMENT/CONTRACT TERMS:
SIZE OF SHIPMENT:
UNIT OF MEASURE:

ADJUSTMENTS TO PRICE	**VALUE/TERMS**	**ALREADY APPLIED TO REPORTED PRICE**
TYPE OF DISCOUNT:		
TYPE OF SURCHARGE:		

REMARKS

THE LATEST TYPE OF PRICE REPORTED WAS (Price for actual shipments are desired):

NET TRANSACTION (ACTUAL SHIPMENT)

PRICE INFORMATION

Please review the previously reported prices. Enter missing prices if available or correct any incorrect prices that are shown.

Please enter the current price in the boxes provided ONLY if there has been a change from the price you previously reported.

	PREVIOUSLY REPORTED PRICES	CORRECTIONS
ON January 13, 2009 THE PRICE WAS	$X.XXXX	________
ON February 10, 2009 THE PRICE WAS	$X.XXXX	________
ON March 10, 2009 THE PRICE WAS	$X.XXXX	________
ON April 14, 2009 THE PRICE WAS	$X.XXXX	________

Did the price change between April 14, 2003 and May 12, 2009?
If 'YES', please report the price of the last shipment since May 1
If there was no shipment in May, please estimate the
Price you would have charged on May 12, 2009.
YES ☐ NO ☐

USE BLACK PEN/
PENCIL ONLY.
DO NOT USE BLUE.

$ ☐☐☐,☐☐☐,☐☐☐.☐☐☐☐ (DOLLARS / CENTS)

PER JOB

SE/OC MMMMMMMMMMMM

REPORTER NAME
REPORTER TITLE
COMPANY NAME
STREET ADDRESS
CITY, STATE
ZIP CODE

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

This table reports average frequencies of price adjustments at the industry and aggregate levels with standard deviations in parentheses for different measures of the frequency of price adjustment. FPA treats missing values as interrupting price spells; for FPB, missing values do not interrupt price spells if the price is the same before and after periods of missing values. FPC forms the union of the two. Columns (1) to (3) use equally-weighted frequencies of price adjustments, whereas columns (4) to (6) weight frequencies with associated values of shipments. Frequencies of price adjustments are calculated at the firm level using the microdata underlying the Producer Price Index constructed by the Bureau of Labor Statistics.

		FPA	FPB	FPC	FPAW	FPBW	FPCW
		(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	Mean	26.96%	27.67%	27.84%	30.11%	30.85%	31.05%
	Std	17.91%	18.06%	18.23%	19.55%	19.62%	19.83%
	Nobs		52			51	
Manufacturing	Mean	11.57%	12.66%	12.72%	12.40%	13.54%	13.62%
	Std	11.19%	11.35%	11.41%	12.90%	12.98%	13.06%
	Nobs		342			336	
Utilities	Mean	19.12%	20.76%	20.91%	19.89%	21.45%	21.59%
	Std	13.93%	13.50%	13.53%	14.44%	14.06%	14.09%
	Nobs		109			105	
Trade	Mean	19.70%	21.58%	21.69%	20.58%	22.55%	22.66%
	Std	13.50%	13.25%	13.34%	13.39%	12.89%	13.00%
	Nobs		45			44	
Finance	Mean	13.14%	18.57%	18.69%	13.17%	20.06%	20.20%
	Std	11.63%	13.00%	13.11%	12.27%	15.05%	15.19%
	Nobs		138			135	
Service	Mean	8.47%	10.37%	10.42%	8.79%	10.51%	10.56%
	Std	8.85%	9.85%	9.88%	8.89%	9.58%	9.59%
	Nobs		74			70	
Total	Mean	14.17%	16.23%	16.32%	14.97%	17.29%	17.40%
	Std	13.07%	13.39%	13.48%	14.28%	14.77%	14.87%
	Nobs		760			741	

Table 2: **Response of the S&P500 to Monetary Policy Shocks**

This table reports the results of regressing returns and squared returns in percent of the S&P500 in an event window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2) in the main body of the paper, v_t*, and the squared shocks,* v_t^2*, for different event types. Columns (1) to (6) look at a 30 minutes window bracketing the FOMC press releases whereas regressions (7) to (12) consider a 60 minutes event window around the release times. The return of the S&P500 is calculated as a weighted average of the constituents' return in the respective event window, where the market capitilization at the end of the previous trading day is used to calculate the weights. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Robust standard errors are reported in parentheses.*

	Returns		Squared Returns				Returns		Squared Returns			
		pre 2005	All	Regular	Turning Point	Intermeeting		pre 2005	All	Regular	Turning Point	Intermeeting
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	−0.08	−0.12*	0.13	0.23***	−0.36	2.68	0.03	−0.04	0.32*	0.38***	0.15	3.44
	(0.06)	(0.05)	(0.13)	(0.05)	(0.77)	(1.64)	(0.07)	(0.06)	(0.16)	(0.09)	(0.67)	(1.46)
v_t	−1.66	−5.31***					−1.35	−5.49***				
	(2.93)	(1.41)					(2.66)	(1.06)				
v_t^2			84.38***	9.57	116.60***	67.15			72.46*	4.27	89.16***	57.84
			(23.18)	(8.67)	(9.68)	(38.79)			(28.11)	(6.89)	(10.45)	(45.93)
R^2	0.03	0.44	0.69	0.02	0.92	0.53	0.02	0.42	0.55	0.00	0.88	0.41
Observations	137	92	137	121	8	8	137	92	137	121	8	8

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

Table 3: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (measure FPB)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures-based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPB, as well as their interactions. See specification (3) in the main body of the paper. FPB treats missing values as not interrupting price spells if the price is the same before and after periods of missing values. Equally-weighted frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. Columns (1) and (2) consider a 30 minutes event window, (3) and (4) add firm fixed effects, (5) and (6) add firm and event fixed effects, (7) and (8) focus on a 60 minutes event window, and (9) and (10) look at daily event windows. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	123.70***	73.18***	122.70***	72.99***			114.70***	89.34***	247.50**	162.00**
	(26.81)	(16.24)	(26.70)	(16.04)			(37.72)	(23.49)	(123.00)	(67.27)
$FPB \times v_t^2$	−121.90*	−41.10***	−119.90**	−41.32***	−117.60*	−16.88*	−86.00	−44.80**	−314.00	−104.90
	(61.75)	(6.98)	(59.54)	(6.95)	(61.64)	(9.81)	(65.28)	(20.13)	(230.50)	(106.00)
FPB	0.84**	0.48***					0.98*	0.62**	1.21	−0.49
	(0.32)	(0.17)					(0.54)	(0.25)	(2.57)	(2.32)
Event Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.11	0.09					0.03	0.08	0.01	0.00
Observations	57,541	57,439	57,541	57,437	57,541	57,411	57,541	55,018	57,541	57,510

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

Table 4: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (measure FPC)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPC, as well as their interactions. See specification (3) in the main body of the paper. FPC forms the union of FPA and FPB. Equally-weighted frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. Columns (1) and (2) consider a 30 minutes event window, (3) and (4) add firm fixed effects, (5) and (6) add firm and event fixed effects, (7) and (8) focus on a 60 minutes event window, and (9) and (10) look at daily event windows. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	123.60***	73.66***	122.50***	73.47***			114.60***	89.26***	247.20**	161.70**
	(26.79)	(16.17)	(26.68)	(15.98)			(37.68)	(23.50)	(122.70)	(67.06)
$FPC \times v_t^2$	−120.30*	−38.05***	−118.30**	−38.30***	−116.20*	−16.69*	−84.77	−44.10**	−310.20	−102.50
	(60.99)	(6.25)	(58.79)	(6.22)	(60.81)	(9.57)	(64.44)	(19.72)	(227.50)	(104.60)
FPC	0.83**	0.47***					0.98*	0.61**	1.22	−0.50
	(0.32)	(0.17)					(0.55)	(0.25)	(2.56)	(2.30)
Event Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.11	0.09					0.03	0.08	0.01	0.00
Observations	57,541	57,441	57,541	57,439	57,541	57,411	57,541	55,018	57,541	57,510

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

Table 5: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (measure FPAW)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPAW, as well as their interactions. See specification (3) in the main body of the paper. FPAW treats missing values as interrupting price spells. Value of shipments weighted-frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. Columns (1) and (2) consider a 30 minutes event window, (3) and (4) add firm fixed effects, (5) and (6) add firm and event fixed effects, (7) and (8) focus on a 60 minutes event window, and (9) and (10) look at daily event windows. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	127.80***	79.07***	126.80***	78.62***			119.40***	96.35***	251.20 * *	164.90 * *
	(29.69)	(15.87)	(29.63)	(15.37)			(39.00)	(25.25)	(122.70)	(76.09)
$FPAW \times v_t^2$	−159.90*	−66.91***	−157.20*	−65.77***	−156.30*	−39.26***	−125.90	−84.83***	−356.40	−181.70
	(82.55)	(4.77)	(80.86)	(4.49)	(81.09)	(7.92)	(78.26)	(22.74)	(245.20)	(113.00)
$FPAW$	0.22	0.05					0.02	−0.08	−0.59	−2.77
	(0.30)	(0.14)					(0.32)	(0.13)	(2.38)	(1.97)
Event Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.11					0.03	0.09	0.01	0.00
Observations	56,409	56,314	56,409	56,316	56,409	56,295	56,409	53,899	56,409	56,379

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

Table 6: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (measure FPBW)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPBW, as well as their interactions. See specification (3) in the main body of the paper. FPBW treats missing values as not interrupting price spells if the price is the same before and after periods of missing values. Value of shipments weighted-frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. Columns (1) and (2) consider a 30 minutes event window, (3) and (4) add firm fixed effects, (5) and (6) add firm and event fixed effects, (7) and (8) focus on a 60 minutes event window, and (9) and (10) look at daily event windows. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	123.40***	75.24***	122.30***	74.69***			114.60***	91.69***	254.30**	156.20**
	(27.21)	(16.14)	(27.09)	(15.64)			(37.75)	(24.33)	(126.90)	(73.32)
$FPBW \times v_t^2$	−116.10*	−37.32***	−113.50*	−35.15***	−111.40*	−17.90*	−83.53	−52.30**	−333.20	−119.80
	(65.12)	(5.86)	(63.32)	(5.84)	(64.96)	(10.19)	(65.96)	(21.15)	(241.30)	(97.19)
$FPBW$	0.67**	0.52***					0.42	0.58***	0.56	−0.97
	(0.28)	(0.19)					(0.28)	(0.22)	(2.19)	(1.91)
Event Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.11					0.03	0.04	0.01	0.00
Observations	56,409	56,314	56,409	56,313	56,409	56,284	56,409	53,896	56,409	56,378

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

Table 7: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (measure FPCW)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPCW, as well as their interactions. See specification (3) in the main body of the paper. FPCW forms the union of FPAW and FPBW. Value of shipments-weighted frequencies of price adjustments are calculated at the establishment level using the microdata underlying the producer price index. Columns (1) and (2) consider a 30 minutes event window, (3) and (4) add firm fixed effects, (5) and (6) add firm and event fixed effects, (7) and (8) focus on a 60 minutes event window, and (9) and (10) look at daily event windows. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	Tight Window		Firm FE		Firm & Event FE		Wide Window		Daily Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	123.40***	75.08***	122.20***	74.52***			114.50***	91.59***	253.90**	155.00**
	(27.20)	(15.98)	(27.08)	(15.62)			(37.74)	(24.35)	(126.50)	(73.01)
$FPCW \times v_t^2$	−114.80*	−38.11***	−112.30*	−34.42***	−110.30*	−16.26*	−82.53	−51.28**	−328.70	−109.80
	(64.29)	(5.46)	(62.51)	(5.49)	(64.06)	(9.59)	(65.11)	(20.84)	(237.60)	(95.37)
$FPCW$	0.66**	0.52***					0.41	0.57***	0.57	−1.63
	(0.27)	(0.18)					(0.27)	(0.22)	(2.18)	(1.78)
Event Fixed Effects	No	No	No	No	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.11					0.03	0.04	0.01	0.00
Observations	56,409	56,315	56,409	56,313	56,409	56,285	56,409	53,897	56,409	56,377

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

Table 8: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (firm & industry level controls, FF adj returns)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPA, as well as their interactions. See specification (3) in the main body of the paper. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. pcm is the price cost margin defined as sales minus cost of goods sold over sales, $4F - conc\ ratio$ is the four-firm concentration ratio, bm is the book-to-market ratio and size is the logarithm of the market capitalization. std sale is the volatility of annual sales growth at the quarterly frequency, nondur, serv, invest, gov and nx follow the durable goods classification of Gomes et al. (2009), dura is the durability measure of Bils et al. (2012), labor share is the share of total staff expenses in sales, FWA is the frequency of wage adjustment of Barattieri et al. (2014), RecPay2Y is receivables minus payables to sales, I2Y is investment to sales and D2A is depreciation and amortization over total assets. engel are the Engel curve slopes of Bils et al. (2012), sync is the degree of synchronization in price adjustment at the firm level, #prod is the number of products in the producer price data, Rat is the S&P long-term issuer rating, KZ is the Kaplan-Zingales index, Lev is financial leverage, FC2Y is fixed costs to sales, and export is the fraction of foreign sales in total sales. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	25.86***	21.62***	29.41***	94.44***	42.10*	17.69***	26.61***	23.42***	23.27***	14.53*
	(4.65)	(2.94)	(3.95)	(34.11)	(25.08)	(3.13)	(8.47)	(3.38)	(6.93)	(7.97)
$FPA \times v_t^2$	−23.10***	−23.24***	−22.90***	−27.81***	−23.65***	−26.21***	−14.42**	−17.51***	0.21	−21.24***
	(4.48)	(5.41)	(4.64)	(3.59)	(4.14)	(3.54)	(5.63)	(3.67)	(7.21)	(2.91)
$v_t^2 \times pcm$		9.63								
		(6.96)								
$v_t^2 \times 4F - conc\ ratio$			−22.21***							
			(5.39)							
$v_t^2 \times bm$				4.50**						
				(2.25)						
$v_t^2 \times size$					−1.00					
					(1.49)					
$v_t^2 \times std\ sale$						130.50***				
						(21.52)				
$v_t^2 \times nondur$							−7.65			
							(5.97)			
$v_t^2 \times serv$							−7.19			
							(7.23)			
$v_t^2 \times invest$							−1.58			
							(3.78)			
$v_t^2 \times gov$							9.78***			
							(3.53)			
$v_t^2 \times nx$							1.26			
							(8.43)			
$v_t^2 \times dura$								1.70		
								(1.42)		
$v_t^2 \times labor\ share$									−22.98*	
									(11.63)	
$v_t^2 \times FWA$										40.76
										(31.41)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	57,497	51,995	50,186	57,498	57,498	52,003	43,063	47,478	9,767	47,421

Standard errors in parentheses

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

continued on next page

Table 8: **Continued from Previous Page**

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
v_t^2	25.26***	25.57***	25.03***	8.24 * *	27.22***	27.99***	47.20***	21.67***	30.08***	20.12***	23.45***	−18.19
	(4.88)	(4.00)	(3.22)	(3.42)	(5.62)	(5.29)	(12.77)	(3.17)	(5.45)	(3.49)	(3.71)	(53.55)
$FPA \times v_t^2$	−20.58***	−23.52***	−20.92***	−10.53***	−15.33	−18.21***	−19.46***	−19.44***	−20.30***	−18.02***	−13.24***	−40.63 * *
	(4.92)	(4.84)	(5.38)	(3.58)	(13.53)	(3.98)	(5.53)	(4.25)	(3.89)	(1.75)	(3.28)	(15.77)
$v_t^2 \times pcm$												−43.38***
												(13.95)
$v_t^2 \times 4F - conc\ ratio$												−18.38***
												(5.68)
$v_t^2 \times bm$												0.38
												(0.74)
$v_t^2 \times size$												−1.08
												(0.87)
$v_t^2 \times std\ sale_a$												57.35
												(44.37)
$v_t^2 \times nondur$												−0.64
												(8.68)
$v_t^2 \times serv$												−7.47
												(10.68)
$v_t^2 \times invest$												−1.15
												(5.66)
$v_t^2 \times gov$												1.54
												(6.43)
$v_t^2 \times nx$												11.84*
												(6.19)
$v_t^2 \times dura$												2.29*
												(1.32)
$v_t^2 \times labor\ share$												
$v_t^2 \times FWA$												463.60
												(299.70)
$v_t^2 \times RecPay2Y$	6.47***											11.45*
	(2.42)											(6.63)
$v_t^2 \times I2Y$		−1.88										−19.42
		(7.45)										(24.39)
$v_t^2 \times D2A$			4.83									50.30
			(67.28)									(104.20)
$v_t^2 \times engel$				16.59***								−3.78
				(2.79)								(4.29)
$v_t^2 \times sync$					−9.28							83.51 * *
					(17.98)							(33.69)
$v_t^2 \times \#prod$						−0.02						0.01
						(0.01)						(0.01)
$v_t^2 \times Rat$							−6.28 * *					−3.50***
							(2.63)					(0.59)
$v_t^2 \times KZ$								4.29				−0.30
								(2.63)				(0.70)
$v_t^2 \times Lev$									−11.66 * *			−0.80
									(4.53)			(8.89)
$v_t^2 \times FC2Y$										26.64*		49.62***
										(15.22)		(14.90)
$v_t^2 \times export$											0.06	−0.15***
											(0.04)	(0.05)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Correction for outlier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	55,945	55,631	56,205	47,477	57,371	57,500	53,360	56,413	56,456	56,534	31,762	19,942

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

Table 9: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (different thresholds for outliers)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in different event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2)in the main body of the paper, v_t^2, the frequency of price adjustment, FPA, as well as their interactions. See specification (3) in the main body of the paper. Different thresholds for outliers are used. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. Columns (1) to (4) consider a 30 minutes event window, (5) to (8) add firm fixed effects, (9) to (12) add firm and event fixed effects The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses. The last row shows the threshold used to identify outliers. The baseline level of the threshold is 0.1. See text for further details.

	Tight Window				Firm FE				Firm & Event FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
v_t^2	82.37***	76.95***	74.56***	82.65***	81.97***	76.59***	74.41***	82.52***				
	(15.57)	(15.95)	(14.77)	(13.71)	(15.44)	(15.82)	(14.63)	(13.51)				
$FPA \times v_t^2$	−60.94***	−67.26***	−70.01***	−88.10***	−60.34***	−69.05***	−69.00***	−89.50***	−47.03 **	−41.33***	−86.20***	−58.25***
	(13.76)	(5.02)	(11.38)	(20.65)	(12.51)	(4.95)	(12.33)	(19.54)	(18.10)	(5.32)	(18.79)	(10.86)
FPA	−0.02	0.09	0.11	0.22								
	(0.14)	(0.16)	(0.16)	(0.18)								
R^2	0.10	0.12	0.10	0.10	0.16	0.15	0.17	0.15	0.26	0.26	0.29	0.31
Observations	57,474	57,441	57,212	56,848	57,473	57,440	57,202	56,844	57,476	57,420	56,859	57,154
Threshold for outliers	0.150	0.100	0.050	0.025	0.150	0.100	0.050	0.025	0.150	0.100	0.050	0.025

Table 10: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (excluding industries)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy surprises calculated according to equation (2)in the main body of the paper, v_t^2 *and the interaction term with the frequency of price adjustment, FPA excluding one industry at a time. See specification (3)in the main body of the paper. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.*

	All		excl. Agro	excl. Mnfg	excl. Util	excl. Trade	excl. Finance	excl. Service
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
v_t^2	127.50***	77.00***	76.28***	81.68***	76.06***	77.16***	74.61***	77.66***
	(29.45)	(15.78)	(14.72)	(19.25)	(15.55)	(15.51)	(15.09)	(16.40)
$FPA \times v_t^2$	−168.00**	−67.82***	−60.20***	−87.55***	−42.50***	−69.11***	−73.87***	−74.94***
	(80.35)	(4.47)	(3.87)	(13.61)	(3.62)	(5.98)	(6.39)	(5.82)
Correction for outliers	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	57,541	57,441	53,812	29,554	50,047	53,602	47,605	52,585

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

Table 11: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (non-linear effects within industry)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2)in the main body of the paper, v_t^2*, for the quintiles of the frequency of price adjustment distribution. See specification (3) in the main body of the paper. Columns (1) to (5) report quintiles for industry-adjusted frequencies. Columns (6)-(10) pool frequency quintiles across industries. See text for more details.*

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	130.70***	107.00***	113.20***	99.71***	74.04***	136.00***	85.13***	107.30***	101.90***	69.18***
	(37.92)	(19.42)	(31.78)	(25.48)	(18.13)	(44.04)	(21.82)	(34.15)	(25.32)	(21.18)
R^2	0.08	0.11	0.19	0.15	0.11	0.11	0.05	0.19	0.17	0.10
Observations	9,438	12,050	11,429	12,553	12,071	9,192	10,204	10,830	11,273	11,173

Standard errors in parentheses

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

Table 12: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (IV and subsample)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in a 30 minutes window bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPA, as well as their interactions for two subsamples of the data. See specification (3) in the main body of the paper. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. Columns (1) and (2) repeat the baseline results, (3) and (4) estimate the baseline specification for the first subsample, (5) and (6) estimate the baseline specification for the second subsample, (7) and (8) use the frequencies of price adjustment from the first subsample to instrument for the frequencies of the second subsample, and (9) and (10) use the frequencies of price adjustment from the second subsample to instrument for the frequencies of the first subsample. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	baseline		FPA from sample 1		FPA from sample 2		FPA from sample 1 IV: FPA from sample 2		FPA from sample 2 IV: FPA from sample 1	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	128.50***	76.95***	110.00***	72.20***	125.50***	74.75***	110.70***	113.80***	119.80***	104.30***
	(29.50)	(15.95)	(24.78)	(14.71)	(29.31)	(15.00)	(25.03)	(27.01)	(27.96)	(24.16)
$FPA \times v_t^2$	−169.80**	−67.26***	−75.90*	−34.27***	−156.10*	−57.54**	−99.87*	−107.10***	−125.80**	−73.73**
	(82.32)	(5.02)	(39.89)	(9.14)	(80.83)	(9.80)	(51.33)	(38.52)	(54.31)	(29.83)
FPA	0.41	0.09	0.33	0.14	0.32	0.12	0.44	0.23	0.27	0.38
	(0.33)	(0.16)	(0.26)	(0.16)	(0.29)	(0.14)	(0.34)	(0.19)	(0.23)	(0.29)
Correction for outliers	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.12	0.12	0.11	0.11	0.12	0.11	0.11	0.11	0.11	0.11
Observations	57,541	57,441	52,962	52,882	56,322	56,226	52,939	52,239	52,939	52,239

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

Table 13: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (cuts of distribution of NProd)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in different event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPA, as well as their interactions for different percentiles of the distribution of the number of products in the producer price index micro data per firm (NProd). See specification (3) in the main body of the paper. NProdx denotes the x^{th} percentile of the distribution. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	baseline		NProd < NProd50		NProd >= NProd50	
	(1)	(2)	(3)	(4)	(5)	(6)
v_t^2	128.50***	76.95***	165.40***	96.11***	86.75***	53.19***
	(29.50)	(15.95)	(45.42)	(13.26)	(25.95)	(15.87)
$FPA \times v_t^2$	−169.80**	−67.26***	−201.50	−71.03***	−78.06***	−30.52***
	(82.32)	(5.02)	(133.50)	(15.60)	(24.08)	(15.58)
FPA	0.41	0.09	1.17***	0.71***	−0.22	−0.36
	(0.33)	(0.16)	(0.56)	(0.25)	(0.25)	(0.24)
Correction for outlier	No	Yes	No	Yes	No	Yes
R^2	0.12	0.12	0.13	0.19	0.11	0.06
Observations	57,541	57,441	25,270	25,171	32,271	32,170

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

Table 14: **Response of the Constituents of the S&P500 to Monetary Policy Shocks (non-linear effects of FPA)**

This table reports the results of regressing squared percentage returns of the constituents of the S&P500 in different event windows bracketing the FOMC press releases on the federal funds futures based measure of monetary policy shocks calculated according to equation (2) in the main body of the paper, v_t^2, the frequency of price adjustment, FPA, as well as their interactions for different parts of the distribution of frequency of price adjustment. See specification (3) in the main body of the paper. FPAxx denotes the xx^{th} percentile of the distribution. Equally-weighted frequencies of price adjustments are calculated at the firm level using the microdata underlying the producer price index. The full sample ranges from February 1994 through December 2009, excluding the release of September 17, 2001, for a total of 137 observations. Standard errors are clustered at the event level and reported in parentheses.

	FPA < FPA50		FPA >= FPA50		FPA > FPA5		FPA < FPA95		FPA5 <FPA < FPA95	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
v_t^2	161.00***	98.52***	115.30***	84.60***	108.60***	70.08***	132.80***	76.29***	110.70***	65.78***
	(53.46)	(14.15)	(25.29)	(17.17)	(26.24)	(15.71)	(30.99)	(15.92)	(27.38)	(15.79)
$FPA \times v_t^2$	−929.00	−524.00***	−117.20***	−93.39***	−93.77***	−28.05 * *	−215.30 * *	−81.74***	−113.70***	−30.67*
	(873.60)	(65.27)	(25.64)	(11.04)	(27.54)	(10.80)	(99.94)	(10.45)	(31.85)	(15.65)
FPA	−1.40	−1.78	0.29	0.00	0.27	0.00	0.37	0.09	0.15	−0.01
	(3.25)	(1.15)	(0.28)	(0.13)	(0.20)	(0.16)	(0.37)	(0.19)	(0.22)	(0.19)
Correction outlier	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.11	0.07	0.14	0.13	0.11	0.10	0.12	0.12	0.12	0.10
Observations	27,222	27,117	30,319	30,192	53,275	53,171	54,670	54,563	50,404	50,290

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

Table 15: **Summary Statistics and Correlations for Firm Characteristics and Explanatory Variables**

This table reports descriptive statistics of various firm characteristics and explanatory variables in Panel A. as well as pairwise correlations in Panel B. FPA is the equally-weighed frequency of price adjustment treating missing values as interrupting price spells, pcm is the price-cost-margin defined as sales minus cost of goods sold over sales, conc ratio is the four-firm concentration ratio, bm is the book-to-market ratio and size is the logarithm of the market capitalization. std sale is the volatility of annual sales growth at the quarterly frequency, Dur follows the durable goods classification of Gomes et al. (2009), dura is the durability measure of Bils et al. (2012), FWA is the frequency of wage adjustment of Barattieri et al. (2014), RecPay2Y is receivables minus payables to sales, I2Y is investment to sales and D2A is depreciation and amortization over total assets. engel are the Engel curve slopes of Bils et al. (2012), sync is the degree of synchronization in price adjustment at the firm level, #prod is the number of products in the producer price data, Rat is the S&P long term issuer rating, KZ the Kaplan-Zingales index, Lev is financial leverage, FC2Y is fixed costs to sales, and export is fraction of foreign sales in total sales. The full sample ranges from February 1994 through December 2009.

	FPA	*beta*	*pcm*	*conc ratio*	*bm*	*size*	$sale_a$	*Dur*	*dura*	*FWA*	*Pay2Y*	*I2Y*	*D2A*	*engel*	*sync*	*#prod*	*Rat*	*KZ*	*Lev*	*FC2Y*	*export*
	Panel A. Descriptive Statistics																				
Mean	0.14	1.00	0.40	0.15	-14.53	15.62	0.07	3.39	0.80	0.16	0.05	0.09	0.04	0.97	0.14	110.59	2.58	1.12	0.40	0.23	16.31
Std	0.13	0.39	0.20	0.09	1.37	1.24	0.06	1.26	1.01	0.01	0.53	0.13	0.02	0.33	0.11	124.54	1.21	0.98	0.24	0.23	15.85
Nobs	760	956	917	839	957	957	917	681	793	768	927	913	926	793	773	778	934	939	939	939	434
10^{th}	0.01	0.60	0.15	0.06	-15.52	14.25	0.02	2.00	0.00	0.15	-0.08	0.01	0.00	0.49	0.04	15.29	0.00	-0.01	0.10	0.00	1.55
25^{th}	0.04	0.74	0.24	0.09	-15.04	15.03	0.03	2.00	0.00	0.15	0.01	0.03	0.03	0.80	0.06	28.17	2.30	0.64	0.23	0.06	5.54
50^{th}	0.10	0.93	0.37	0.14	-14.64	15.62	0.05	3.00	0.20	0.15	0.06	0.06	0.04	0.96	0.11	64.18	3.00	1.13	0.39	0.19	11.36
75^{th}	0.22	1.19	0.56	0.18	-14.20	16.31	0.08	4.00	1.63	0.17	0.12	0.10	0.05	1.18	0.21	146.51	3.40	1.73	0.57	0.32	22.04
90^{th}	0.33	1.51	0.70	0.26	-13.82	17.03	0.12	5.00	2.27	0.18	0.20	0.20	0.07	1.44	0.29	293.09	3.65	2.29	0.72	0.51	36.88
	Panel B. Pairwise Correlations																				
FPA	1																				
beta	-0.13	1																			
pcm	-0.14	0.19	1																		
conc ratio	0.01	-0.08	-0.05	1																	
bm	0.1	-0.07	-0.19	0	1																
size	0.03	0.07	0.25	0.09	-0.34	1															
$sale_a$	0.02	0.31	0.14	-0.08	-0.04	0.03	1														
Dur	0.03	0.33	0.03	-0.22	-0.07	-0.04	0.13	1													
dura	-0.14	0.24	-0.13	0.07	-0.05	-0.21	-0.04	0.29	1												
FWA	0.27	-0.06	-0.05	-0.35	0.09	0.03	0.18	0.2	-0.47	1											
Pay2Y	-0.04	0.04	-0.07	0	0.04	0	0.04	0.04	0.03	-0.15	1										
I2Y	0.29	0	0.19	0.02	0.01	0.04	0.25	0.07	-0.17	0.37	-0.06	1									
D2A	0.19	-0.06	0.01	0.2	0	-0.12	-0.03	0.15	0.12	0.16	0.04	0.44	1								
engel	-0.26	0.33	0.18	-0.34	0.01	-0.04	0.1	0.25	0.08	-0.08	-0.01	-0.23	-0.3	1							
sync	0.83	-0.14	-0.13	0.03	0.12	0.01	0.02	0.02	-0.2	0.34	-0.07	0.4	0.22	-0.29	1						
#prod	0.2	-0.27	-0.25	0.14	0.08	0.1	-0.11	-0.17	-0.08	0.05	0.03	0.08	0.07	-0.32	0.22	1					
Rat	0.11	-0.27	-0.15	0.06	0.04	0.33	-0.18	-0.26	-0.14	-0.1	-0.03	-0.06	-0.14	-0.14	0.11	0.15	1				
KZ	0.11	0.08	-0.03	-0.06	0.27	-0.03	0.15	0.01	-0.06	0.15	0	0.11	-0.17	0.08	0.13	0.04	0.16	1			
Lev	0.16	-0.18	-0.08	0.02	0.35	0.04	-0.07	-0.23	-0.24	0.07	-0.01	0.06	-0.17	-0.1	0.19	0.21	0.42	0.66	1		
FC2Y	-0.28	0.29	0.66	0.04	-0.25	0.06	0.26	0.05	0.14	-0.22	-0.09	0.07	0.13	0.15	-0.3	-0.26	-0.33	-0.12	-0.35	1	
export	-0.12	0.01	0.03	0.01	0.05	0	0.06	0	0.01	-0.1	0.05	-0.11	-0.03	0.06	-0.16	0.03	0.01	-0.01	-0.02	0.1	1

Table 16: **Monetary Policy Surprises**

This table reports the days of the FOMC press releases with exact time stamps as well as the actual changes in the Federal Funds Rate further decomposed into an expected and an unexpected part. The latter component is calculated as the scaled change of the current month federal funds future in a half-hour (tight) window and one-hour (wide) window bracketing the release time according to equation (2) in the main body of the paper.

		Unexpected Change (bps)		Expected Change (bps)		
Release Date	Release Time	Tight Window	Wide Window	Tight Window	Wide Window	Actual Change (bps)
04-Feb-94	11:05:00	16.30	15.20	8.70	9.80	25.00
22-Mar-94	14:20:00	0.00	0.00	25.00	25.00	25.00
18-Apr-94	10:06:00	15.00	15.00	10.00	10.00	25.00
17-May-94	14:26:00	11.10	11.10	38.90	38.90	50.00
06-Jul-94	14:18:00	−5.00	−3.70	5.00	3.70	0.00
16-Aug-94	13:18:00	12.40	14.50	37.60	35.50	50.00
27-Sep-94	14:18:00	−9.00	−9.00	9.00	9.00	0.00
15-Nov-94	14:20:00	12.00	12.00	63.00	63.00	75.00
20-Dec-94	14:17:00	−22.60	−22.60	22.60	22.60	0.00
01-Feb-95	14:15:00	6.20	6.20	43.80	43.80	50.00
28-Mar-95	14:15:00	−1.00	0.00	1.00	0.00	0.00
23-May-95	14:15:00	0.00	0.00	0.00	0.00	0.00
06-Jul-95	14:15:00	−11.20	−7.40	−13.80	−17.60	−25.00
22-Aug-95	14:15:00	3.40	3.40	−3.40	−3.40	0.00
26-Sep-95	14:15:00	3.00	4.00	−3.00	−4.00	0.00
15-Nov-95	14:15:00	4.00	5.00	−4.00	−5.00	0.00
19-Dec-95	14:15:00	−9.00	−10.30	−16.00	−14.70	−25.00
31-Jan-96	14:15:00	−3.00	−3.00	−22.00	−22.00	−25.00
26-Mar-96	11:39:00	1.00	1.00	−1.00	−1.00	0.00
21-May-96	14:15:00	0.00	0.00	0.00	0.00	0.00
03-Jul-96	14:15:00	−7.20	−6.60	7.20	6.60	0.00
20-Aug-96	14:15:00	−2.80	−2.80	2.80	2.80	0.00
24-Sep-96	14:15:00	−12.00	−12.00	12.00	12.00	0.00
13-Nov-96	14:15:00	−1.80	−1.80	1.80	1.80	0.00
17-Dec-96	14:15:00	1.10	0.00	−1.10	0.00	0.00
05-Feb-97	14:15:00	−3.70	−3.00	3.70	3.00	0.00
25-Mar-97	14:15:00	4.00	4.00	21.00	21.00	25.00
20-May-97	14:15:00	−9.90	−9.90	9.90	9.90	0.00
02-Jul-97	14:15:00	−2.10	−1.10	2.10	1.10	0.00
19-Aug-97	14:15:00	0.00	0.00	0.00	0.00	0.00
30-Sep-97	14:15:00	0.00	0.00	0.00	0.00	0.00
12-Nov-97	14:15:00	−4.20	−4.20	4.20	4.20	0.00

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Table 16: **Continued from Previous Page**

		Unexpected Change (bps)		Expected Change (bps)		
Release Date	Release Time	Tight Window	Wide Window	Tight Window	Wide Window	Actual Change (bps)
16-Dec-97	14:15:00	0.00	0.00	0.00	0.00	0.00
04-Feb-98	14:12:00	0.00	0.00	0.00	0.00	0.00
31-Mar-98	14:15:00	−1.00	−1.00	1.00	1.00	0.00
19-May-98	14:15:00	−2.60	−2.60	2.60	2.60	0.00
01-Jul-98	14:15:00	−0.50	−0.50	0.50	0.50	0.00
18-Aug-98	14:15:00	1.20	1.20	−1.20	−1.20	0.00
29-Sep-98	14:15:00	5.00	6.00	−30.00	−31.00	−25.00
15-Oct-98	15:15:00	−24.20	−24.20	−0.80	−0.80	−25.00
17-Nov-98	14:15:00	−6.90	−5.80	−18.10	−19.20	−25.00
22-Dec-98	14:15:00	0.00	−1.70	0.00	1.70	0.00
03-Feb-99	14:12:00	0.60	0.60	−0.60	−0.60	0.00
30-Mar-99	14:12:00	−1.00	0.00	1.00	0.00	0.00
18-May-99	14:11:00	−1.20	−1.20	1.20	1.20	0.00
30-Jun-99	14:15:00	−3.00	−4.00	28.00	29.00	25.00
24-Aug-99	14:15:00	3.50	3.00	21.50	22.00	25.00
05-Oct-99	14:12:00	−4.20	−4.20	4.20	4.20	0.00
16-Nov-99	14:15:00	7.50	9.60	17.50	15.40	25.00
21-Dec-99	14:15:00	1.60	1.60	−1.60	−1.60	0.00
02-Feb-00	14:15:00	−5.90	−5.90	30.90	30.90	25.00
21-Mar-00	14:15:00	−4.70	−4.70	29.70	29.70	25.00
16-May-00	14:15:00	4.10	3.10	45.90	46.90	50.00
28-Jun-00	14:15:00	−2.50	−2.00	2.50	2.00	0.00
22-Aug-00	14:15:00	−1.70	0.00	1.70	0.00	0.00
03-Oct-00	14:12:00	0.00	−0.60	0.00	0.60	0.00
15-Nov-00	14:12:00	−1.00	−1.00	1.00	1.00	0.00
19-Dec-00	14:15:00	6.50	6.50	−6.50	−6.50	0.00
03-Jan-01	13:13:00	−39.30	−36.50	−10.70	−13.50	−50.00
31-Jan-01	14:15:00	3.50	4.00	−53.50	−54.00	−50.00
20-Mar-01	14:15:00	7.10	5.60	−57.10	−55.60	−50.00
18-Apr-01	10:54:00	−43.80	−46.30	−6.20	−3.70	−50.00
15-May-01	14:15:00	−9.70	−7.80	−40.30	−42.20	−50.00
27-Jun-01	14:12:00	10.50	11.00	−35.50	−36.00	−25.00
21-Aug-01	14:15:00	1.60	1.60	−26.60	−26.60	−25.00
02-Oct-01	14:15:00	−3.70	−3.70	−46.30	−46.30	−50.00
06-Nov-01	14:20:00	−15.00	−15.00	−35.00	−35.00	−50.00
11-Dec-01	14:15:00	−0.80	0.00	−24.20	−25.00	−25.00

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Table 16: **Continued from Previous Page**

		Unexpected Change (bps)		Expected Change (bps)		
Release Date	Release Time	Tight Window	Wide Window	Tight Window	Wide Window	Actual Change (bps)
30-Jan-02	14:15:00	2.50	1.50	−2.50	−1.50	0.00
19-Mar-02	14:15:00	−2.60	−2.60	2.60	2.60	0.00
07-May-02	14:15:00	0.70	0.70	−0.70	−0.70	0.00
26-Jun-02	14:15:00	0.00	0.00	0.00	0.00	0.00
13-Aug-02	14:15:00	4.30	4.30	−4.30	−4.30	0.00
24-Sep-02	14:15:00	2.00	2.50	−2.00	−2.50	0.00
06-Nov-02	14:15:00	−20.00	−18.80	−30.00	−31.20	−50.00
10-Dec-02	14:15:00	0.00	0.00	0.00	0.00	0.00
29-Jan-03	14:15:00	1.00	0.50	−1.00	−0.50	0.00
18-Mar-03	14:15:00	2.40	3.60	−2.40	−3.60	0.00
06-May-03	14:15:00	3.70	3.70	−3.70	−3.70	0.00
25-Jun-03	14:15:00	13.50	12.50	−38.50	−37.50	−25.00
12-Aug-03	14:15:00	0.00	0.00	0.00	0.00	0.00
16-Sep-03	14:15:00	1.10	1.10	−1.10	−1.10	0.00
28-Oct-03	14:15:00	−0.50	−0.50	0.50	0.50	0.00
09-Dec-03	14:15:00	0.00	0.00	0.00	0.00	0.00
28-Jan-04	14:15:00	0.50	0.00	−0.50	0.00	0.00
16-Mar-04	14:15:00	0.00	0.00	0.00	0.00	0.00
04-May-04	14:15:00	−1.20	−1.20	1.20	1.20	0.00
30-Jun-04	14:15:00	−0.50	−1.50	25.50	26.50	25.00
10-Aug-04	14:15:00	0.70	1.50	24.30	23.50	25.00
21-Sep-04	14:15:00	0.00	0.00	25.00	25.00	25.00
10-Nov-04	14:15:00	−0.80	0.00	25.80	25.00	25.00
14-Dec-04	14:15:00	−0.90	0.00	25.90	25.00	25.00
02-Feb-05	14:17:00	−0.54	0.00	25.54	25.00	25.00
22-Mar-05	14:17:00	0.00	−0.50	25.00	25.50	25.00
03-May-05	14:16:00	0.00	−0.56	25.00	25.56	25.00
30-Jun-05	14:15:00	−0.50	0.00	25.50	25.00	25.00
09-Aug-05	14:17:00	−0.71	−0.71	25.71	25.71	25.00
20-Sep-05	14:17:00	3.00	4.50	22.00	20.50	25.00
01-Nov-05	14:18:00	−0.52	−0.52	25.52	25.52	25.00
13-Dec-05	14:13:00	0.00	0.00	25.00	25.00	25.00
31-Jan-06	14:14:00	0.50	0.50	24.50	24.50	25.00
28-Mar-06	14:17:00	0.50	0.50	24.50	24.50	25.00
10-May-06	14:17:00	0.00	−0.75	25.00	25.75	25.00
29-Jun-06	14:16:00	−1.00	−1.50	26.00	26.50	25.00

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Table 16: **Continued from Previous Page**

Release Date	Release Time	Unexpected Change (bps) Tight Window	Unexpected Change (bps) Wide Window	Expected Change (bps) Tight Window	Expected Change (bps) Wide Window	Actual Change (bps)
08-Aug-06	14:14:00	−4.77	−4.77	4.77	4.77	0.00
20-Sep-06	14:14:00	−1.50	−1.50	1.50	1.50	0.00
25-Oct-06	14:13:00	−0.50	−0.50	0.50	0.50	0.00
12-Dec-06	14:14:00	0.00	0.00	0.00	0.00	0.00
31-Jan-07	14:14:00	0.00	−0.50	0.00	0.50	0.00
21-Mar-07	14:15:00	1.67	0.00	−1.67	0.00	0.00
09-May-07	14:15:00	0.00	−0.71	0.00	0.71	0.00
28-Jun-07	14:14:00	0.00	0.00	0.00	0.00	0.00
07-Aug-07	14:14:00	0.65	1.30	−0.65	−1.30	0.00
10-Aug-07	09:15:00	1.50	3.00	−1.50	−3.00	0.00
17-Aug-07	08:15:00	4.62	15.00	−4.62	−15.00	0.00
18-Sep-07	14:15:00	−20.00	−21.25	−30.00	−28.75	−50.00
31-Oct-07	14:15:00	−2.00	−2.00	−23.00	−23.00	−25.00
11-Dec-07	14:16:00	3.16	3.16	−28.16	−28.16	−25.00
22-Jan-08	08:21:00	−46.67	−45.00	−28.33	−30.00	−75.00
30-Jan-08	14:14:00	−11.00	−11.00	−39.00	−39.00	−50.00
11-Mar-08	08:30:00	8.68	7.11	−8.68	−7.11	0.00
18-Mar-08	14:14:00	10.00	10.00	−85.00	−85.00	−75.00
30-Apr-08	14:15:00	−6.00	−6.50	−19.00	−18.50	−25.00
25-Jun-08	14:09:00	−1.50	−1.00	1.50	1.00	0.00
05-Aug-08	14:13:00	−0.60	−0.50	0.60	0.50	0.00
16-Sep-08	14:14:00	9.64	11.25	−9.64	−11.25	0.00
08-Oct-08	07:00:00	−12.95	−13.30	−37.05	−36.70	−50.00
29-Oct-08	14:17:00	−3.50	−3.50	−46.50	−46.50	−50.00
16-Dec-08	14:21:00	−16.07	−24.15	−83.93	−75.85	−100.00
28-Jan-09	14:15:00	0.50	0.00	−0.50	0.00	0.00
18-Mar-09	14:17:00	−0.63	−0.63	0.63	0.63	0.00
29-Apr-09	14:16:00	0.00	0.50	0.00	−0.50	0.00
24-Jun-09	14:18:00	0.00	0.00	0.00	0.00	0.00
12-Aug-09	14:16:00	0.00	0.00	0.00	0.00	0.00
23-Sep-09	14:16:00	−1.07	0.00	1.07	0.00	0.00
04-Nov-09	14:18:00	−0.58	−0.58	0.58	0.58	0.00
16-Dec-09	14:15:00	−1.61	−1.07	1.61	1.07	0.00