Monetary Policy and Investment Dynamics: Evidence from Disaggregate Data

Gregory E. Givens[a,*], Robert R. Reed[a]

[a] *Department of Economics, Finance, and Legal Studies, University of Alabama, Tuscaloosa, AL 35487, USA*

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Abstract

We use disaggregated data on the components of private fixed investment (PFI) to estimate industry-level responses of real investment and capital prices to unanticipated monetary policy. The response functions derive from a restricted large-scale VAR estimated over 1959-2007. Our results point to significant cross-sector heterogeneity in the behavior of PFI prices and quantities. For assets belonging to the equipment category of fixed investment, we find that quantities rather than prices absorb most of the fallout from a policy shock. By contrast, the price effects tend to be higher and the output effects lower for nonresidential structures. Consequently, the power of monetary policy to stimulate fixed-capital formation is not uniform across industries.

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*Corresponding author. Tel.: + 205 348 8961.
E-mail address: gegivens@cba.ua.edu (G.E. Givens).

1 Introduction

How quickly and to what extent monetary policy influences economic conditions varies from one sector of the economy to another. This makes the task of central banking difficult because the impetus for policy intervention often depends on the source of weakness or instability in the market. The 2001 recession, for example, was accompanied by declining private expenditures on capital equipment. The press release following the January 31, 2001 meeting of the Federal Open Market Committee (FOMC) stated that "business spending on capital equipment [has] weakened appreciably." The recession of 2007-2009, on the other hand, was greatly intensified by a collapse in residential investment. Official policy statements published after the August 5, 2008 FOMC meeting proclaimed that "the ongoing housing contraction ... [is] likely to weigh on economic growth over the next few quarters."

Given the status that investment-related activity has in FOMC deliberations, this paper empirically examines how conditions across all the private fixed investment categories reported by the Bureau of Economic Analysis (BEA) respond to aggregate monetary shocks. To date, there are a total of 67 distinct fixed investment types represented in the data that underlie the National Income and Product Accounts (NIPA). Examples include commercial warehouses, lodgings, mining and oilfield machinery, railroad equipment, and single-family housing.[1] For each of these industry groups, the BEA publishes quarterly data on both nominal expenditures and the price level. Our main goal here is to document potential cross-sector differences in the response of these disaggregated series to unanticipated monetary policy.

We focus on exposing asymmetries not only in the magnitude of the price and quantity responses, but also in the speed with which policy actions are transmitted to the many diverse capital-goods producing industries. An analysis of the cross-sectional results also allows us to see if there are any systematic relationships among prices and quantities within

[1]See Table A in the appendix for a complete list of the separate components of private fixed investment.

more broadly-defined asset categories like residential structures, nonresidential structures, and durable equipment. Our findings can therefore provide evidence on whether market conditions in related industries react similarly to aggregate shocks.

The notion that monetary policy affects various sectors of the economy differently is not new. There is a large body of research that studies the impact of policy disturbances on a wide range of disaggregated prices and quantities, and the results overwhelmingly point to sizable and significant cross-sector heterogeneity. Lastrapes (2006) and Balke and Wynne (2007) demonstrate that policy shocks alter the distribution of prices comprising the numerous industry components of the Producer Price Index. The authors interpret these relative price movements as evidence of monetary nonneutrality. Bils, Klenow, and Kryvtsov (2003) and Altissimo, Mojon, and Zaffaroni (2009) draw similar conclusions for the major retail price categories found in the US and euro area Consumer Price Index, respectively.[2] Using industry-level data, Barth and Ramey (2002), Dedola and Lippi (2005), and Loo and Lastrapes (1998) report substantial heterogeneity in sectoral output responses to a monetary shock. Carlino and Defina (1998) examine the policy effects on real personal income in the eight BEA regions of the United States. They find evidence of asymmetry in the response patterns and trace this result to differences in certain industry characteristics across regions.

Despite the many contributions that deal with the sectoral effects of monetary policy, the literature is largely silent on whether changes in policy influence the various types of investment activity differently.[3] This is somewhat troubling insofar as investment is a major source of economic activity and an integral component of the policy transmission mechanism central to models of the business cycle. Nevertheless, existing empirical studies focus on aggregate investment and disregard information contained in disaggregate data (e.g., Bernanke and

[2] In a related set of papers, Clark (2006), Boivin, Giannoni, and Mihov (2009), and Baumeister, Liu, and Mumtaz (2013) use disaggregate data to assess differences between aggregate and sectoral inflation dynamics. Enders and Ma (2011) show that the volatility declines experienced during the so-called Great Moderation era did not occur simultaneously across all sectors of the US economy.

[3] Recent theoretical contributions include Erceg and Levin (2006) and Barsky, House, and Kimball (2007).

Gertler, 1995; Christiano, Eichenbaum, and Evans, 1999). Our paper aims to fill this void, and by doing so, contributes to the policy discussion in two ways. First, central banks want to know how their actions affect conditions across the full spectrum of capital-producing industries. Our results help inform policymakers by exposing differences in the response to a monetary shock among all the major investment categories represented in the NIPA. Second, the stylized facts that emerge from this study can serve as benchmarks for developing and evaluating more comprehensive models of the monetary transmission mechanism.

To obtain the responses of industry-level prices and quantities, we employ a quarterly structural vector autoregression (VAR) and identify monetary shocks as orthogonalized innovations to the federal funds rate. Our estimation period is 1959 to 2007. As shown by Sims (1992) and Bernanke and Blinder (1992), the VAR is a useful framework for estimating the dynamic effects of monetary policy innovations. To preserve degrees of freedom, however, estimated VARs typically involve a limited number of macroeconomic variables. Incorporating a broad panel of disaggregated investment data would obviously violate this practice and, absent restrictions on the model, make estimation infeasible for any suitable lag choice.

In this paper we avoid problems associated with most large-scale VARs by adopting an empirical strategy used by Barth and Ramey (2002) and formalized in Lastrapes (2005). The procedure calls for segmenting the VAR into two blocks, the first containing macroeconomic aggregates or 'common factors' and the second containing industry variables. Degrees of freedom are preserved by assuming (*i*) common factors are independent of the industry block and (*ii*) variables in the latter subset are mutually independent after conditioning on the former. Under these conditions least squares is efficient and monetary policy innovations can be identified through restrictions on just the macro-variable equations.

Estimation results show that policy outcomes are not uniform across capital-producing industries. While most, but not all, prices and quantities increase after a monetary expansion, there is significant cross-sectional variation in the size and speed of the adjustment paths. The implication is that monetary policy has distributional effects, not only on the composition of fixed investment but also on the dispersion of relative prices.

While the full set of response functions indicate widespread heterogeneity, isolating certain industry subgroups reveals some compelling similarities in the way prices and quantities interact over time. Notably, monetary policy appears capable of boosting real activity among producers of durable equipment. Results show that where production volumes tend to respond swiftly to policy shocks, equipment prices often react sluggishly. By contrast, in markets for residential structures, expansionary shocks translate quickly into both higher prices and higher quantities. Where policy appears least effective in motivating capital formation is in nonresidential structures. Here evidence suggests that producers usually raise prices in the short run rather than adjust quantities. A comprehensive understanding of these sorts of relationships is important for the conduct of monetary policy. At the very least they suggest that the ability of policy to stimulate investment activity depends on the particular area of weakness among capital-producing industries.

2 Investment Data

Source data on nominal expenditures and price indexes for all categories of private fixed investment (PFI) come from the Underlying Detail Tables for Gross Domestic Product reported (online) by the BEA.[4] The tables disassemble PFI into various components, the number of which differ by level of aggregation. There are only two components reported at the highest aggregation level, residential and nonresidential investment. The former comprises residential investment in structures and equipment while the latter consists of nonresidential structures, equipment, and a third group encompassing items described as intellectual property prod-

[4]http://www.bea.gov/iTable/index_UD.cfm/

ucts.[5] The underlying data decompose PFI further into 16 separate subcategories covering more narrowly-defined sectors of the economy. This third level of aggregation includes series such as commercial and health care buildings, transportation equipment, software, and permanent-site residential structures.

Sinking even further in the detailed NIPA estimates reveals as many as 67 individual series spanning all of PFI. They represent the most disaggregate measures available in the underlying data, and most of them summarize investment activity within a specific industry. Examples include food and beverage establishments, religious structures, photocopy equipment, farm tractors, and dormitories. Table A in the appendix lists all of the component series of PFI and organizes them by aggregation level. The table also reports nominal spending on each disaggregate as a percentage share of total private fixed investment in 2007.

The estimation exercises carried out in this paper employ a panel of investment data assembled at the most detailed aggregation level published by the BEA. The panel consists of disaggregate price and quantity series for the numerous components listed in Table A. In the majority of cases, data on these measures are available on a quarterly basis from 1959 through the present. A small number of these series, however, were excluded from the analysis because of missing observations. In such instances, the offending series were replaced by data from the next lowest level of aggregation.[6] This left us with a total of 64 disaggregate series on PFI prices and an equal number of series on nominal investment. The set of variables omitted from our panel represented just 3.4% of PFI expenditures in 2007.[7]

[5] Intellectual property products were grouped and re-classified as a component of nonresidential fixed investment as part of the comprehensive revision to the NIPA in July of 2013.

[6] Separate data on light trucks, including utility vehicles, and other trucks, buses, and truck trailers (lines 56 and 57 of Table A) are not available before 1987. We therefore replace these series with aggregate data on trucks, buses, and truck trailers (line 55), which appear without interruption from 1959 on.

[7] The BEA does not compute price indexes for net purchases of used residential or nonresidential structures (lines 34 and 93 of Table A). Both quantities are therefore excluded from the panel.

3 Empirical Framework

We are interested in characterizing the effects of exogenous monetary shocks on the cross-sectional variation among investment prices and real investment spending. Following in the tradition of Bernanke and Blinder (1992) and Christiano *et al.* (1999), we employ a vector autoregression and identify monetary shocks as innovations to the federal funds rate.

One complication that emerges from our use of disaggregate data concerns the large dimensionality of a VAR that includes, among other variables, 128 different PFI prices and quantities. Without placing additional restrictions on the model, insufficient observations and a loss of degrees of freedom make estimation infeasible. To address this problem, we borrow from Barth and Ramey (2002) and Lastrapes (2005) by partitioning the variables into two blocks. The first block consists of macroeconomic variables or 'common factors' that appear regularly in the monetary VAR literature. It includes real gross domestic product (GDP), the GDP chain-type price index (P), total private fixed investment (PFI), the deflator for private fixed investment (Q), the ratio of crude materials to finished goods in the Producer Price Index (PCM), the effective federal funds rate (FFR), and the ratio of nonborrowed to total reserves (NTR).[8] The second block consists of only two equations at a time, one for the disaggregate price series of interest and the other for its corresponding real quantity. Efficient estimation and consistent identification of the FFR shock can be obtained by imposing exclusion restrictions on the set of coefficients in the macro-variable equations that govern feedback from the disaggregate series. This ensures that common factors are independent of the industry variables since the feedback coefficients of the former are fixed across regressions. Coefficients of the disaggregate series are permitted to vary with each industry examined.[9]

[8]We include the relative price of crude materials in order to mitigate the "price puzzle," a temporary deflation following a negative funds rate shock. Sims (1992) points out that such inconsistencies are the result of omitting variables from the VAR that provide information on expected future inflation.

[9]Using similar restrictions to estimate sectoral responses to oil shocks, Davis and Haltiwanger (2001) argue that the resultant system is equivalent to a pseudo-panel-data VAR.

The relationship between aggregate and industry variables can be seen more clearly by considering the VAR process

$$Z_t = \mu + A(L)Z_{t-1} + \epsilon_t, \qquad (1)$$

where $Z_t' = [\mathrm{GDP}_t\ \mathrm{P}_t\ \mathrm{PFI}_t\ \mathrm{Q}_t\ \mathrm{PCM}_t\ \mathrm{FFR}_t\ \mathrm{NTR}_t\ \mathrm{i}_{j,t}\ \mathrm{q}_{j,t}]$, μ is a vector of constants, $A(L)$ is a conformable lag polynomial of finite order, and the error term $\epsilon_t \sim$ i.i.d. $(0, \Omega)$. The quantities $\mathrm{i}_{j,t}$ and $\mathrm{q}_{j,t}$ denote real spending and the price deflator, respectively, on investment goods from industry j. Independence of the first seven variables from $\mathrm{i}_{j,t}$ and $\mathrm{q}_{j,t}$ is obtained by imposing restrictions on the lag polynomial of the form

$$\underset{9\times 9}{A}(k) = \begin{bmatrix} \underset{7\times 7}{A_{1,1}(k)} & \underset{7\times 2}{0} \\ \underset{2\times 7}{A_{2,1}(k)} & \underset{2\times 2}{A_{2,2}(k)} \end{bmatrix}$$

for all k lags. These restrictions imply that macroeconomic aggregates are unaffected by variations in the disaggregate series. It follows that estimation and identification of monetary shocks will be the same regardless of which price-quantity industry pair is used in the VAR.

By including only one ($\mathrm{i}_{j,t}$, $\mathrm{q}_{j,t}$) combination at a time, we are also assuming that the full set of investment prices and quantities are mutually independent after conditioning on the first seven common factors. Thus any observed correlation across industries is accounted for by their joint dependence on the aggregate macro variables. Had we expanded Z_t to consider all industries simultaneously, the assumption of mutual independence would impose a block-diagonal structure on the matrix $A_{2,2}(k)$ (a 128×128 object in this case) for all k lags. That is to say, each pair of ($\mathrm{i}_{j,t}$, $\mathrm{q}_{j,t}$) equations would contain only its own lagged values as well as lags of the common factors. This is equivalent to estimating our 9-variable system separately for each industry category while leaving the 2×2 partitions $A_{2,2}(k)$ completely unrestricted.

To identify monetary shocks, we adopt the recursiveness approach described in Christiano *et al.* (1999). The procedure begins by specifying a relationship between structural disturbances (ν_t) and reduced-form errors (ϵ_t) of the form $\epsilon_t = S\nu_t$, where S is a 9×9 contemporaneous matrix. It follows that (1) can be written in terms of structural shocks as

$$Z_t = B(L)\left(\mu + S\nu_t\right), \tag{2}$$

where $B(L) \equiv (I - A(L)L)^{-1}$ is a convergent infinite-order lag polynomial. Here monetary shocks are interpreted as structural innovations to the federal funds rate, corresponding to the sixth element of ν_t in the transformed system (2). The impulse responses of Z_t to a policy shock are summarized by the matrix polynomial $B(L)S$.

The elements of $B(L)$ and S are estimated in two steps. First, we use ordinary least squares on (1) to obtain estimates of $A(L)$ and ϵ_t. We then impose orthogonality and normalization (unit variance) restrictions on the covariance matrix of ν_t along with triangular restrictions on the matrix S. This allows us to identify S from a standard Choleski decomposition of Ω. Given estimates of $A(L)$, estimates of $B(L)$ are derived from $B(L) = (I - A(L)L)^{-1}$.

Imposing a lower triangular structure on S is motivated by assumptions regarding time lags in the transmission of monetary shocks to the broader economy. One assumption is that the common factors appearing above FFR_t in (1) react to a policy innovation with a one-quarter delay. These restrictions are met by inserting zeros in the first five elements of the sixth column of S. A second assumption is that variables below the funds rate may react contemporaneously (within the same quarter) to an FFR shock. The last four coefficients in the sixth column of S are therefore kept free. Note that by ordering $\mathrm{i}_{j,t}$ and $\mathrm{q}_{j,t}$ last, we are assuming monetary shocks can affect industry variables before they affect the macro variables (excluding NTR).[10] No additional timing restrictions are needed to achieve identification.[11]

[10] An alternative view is that policy shocks should affect both macro and industry-level variables no sooner than with a one-quarter lag. In this case $\mathrm{i}_{j,t}$ and $\mathrm{q}_{j,t}$ must be positioned above FFR_t in (1). It turns out that such a re-ordering has little effect on our main quantitative results since the large majority of impact-period responses of the industry variables are not significantly different from zero (see Fig. 3).

[11] As shown by Christiano *et al.* (1999), the set of response functions are invariant to the specific ordering of variables within the two groups above and below the funds rate.

The dataset consists of quarterly observations covering 1959:Q1 to 2007:Q4.[12] All series except FFR_t are expressed in natural-log levels. Real investment spending for industry j is the ratio of nominal expenditures to the industry price index described in the previous section. Finally, four lags of each variable are used in estimating (1). We found this number was sufficient to stamp out the serial correlation in both macro and industry-level residuals.[13]

4 Empirical Findings

4.1 Aggregate Responses to a Policy Shock

Before commenting on the industry response functions, we verify that our estimated VAR generates aggregate dynamics consistent with known findings. Fig. 1 plots impulse responses for GDP_t, P_t, PCM_t, FFR_t, and NTR_t to a one standard deviation (71 basis point) drop in the federal funds rate. Shaded regions correspond to 90 percent confidence bands.[14]

The aggregate effects of an expansionary FFR innovation can be summarized as follows. First, there is a persistent decline in the funds rate accompanied by a large and persistent increase in the ratio of nonborrowed to total reserves. Estimates suggest that it takes over a year for both quantities to return to pre-shock levels. Second, real GDP exhibits the usual hump-shaped pattern seen in numerous empirical studies (e.g., Leeper, Sims, and Zha, 1996). Here we find that it reaches a peak of 0.65 percent roughly six quarters after the shock. Third, after a delay of five quarters, the chain-type price index for GDP starts climbing to

[12] We exclude dates covering the financial crisis and recovery. During this period, nonborrowed reserves became negative due to injections of borrowed reserves through the Term Auction Facility. This is problematic for estimation since the relevant variable is the natural log of the ratio of nonborrowed to total reserves.

[13] Ljung-Box Q tests fail to reject the hypothesis of no serial correlation in the residuals at the 5% level.

[14] Confidence bands are computed using Monte Carlo methods. We first take the joint distribution of the VAR coefficients and the residual covariance matrix to be asymptotically normal with mean equaling the sample estimates and covariance equaling the sample covariance matrix of those estimates. We then draw $10,000$ random vectors from this normal distribution and, preserving the identification restrictions, compute impulse response functions for each draw. Ninety percent confidence bands correspond to the 5^{th} and 95^{th} percent bounds of the simulated distribution of impulse response functions over all $10,000$ trials.

a permanently higher level. Four years after the shock, however, it is still only 0.64 percent above the baseline. Results showing that aggregate prices respond sluggishly to a policy shock appear frequently in the VAR literature (e.g., Christiano *et al.*, 1999). Fourth, a funds rate shock generates a large and sustained increase in the relative price of crude materials. The maximum impact is nearly 2 percent and occurs at a horizon of three years.

4.2 Disaggregate Responses to a Policy Shock

In this section we analyze the responses of our disaggregate investment series to an expansionary monetary policy shock, that is, an unanticipated reduction (of 71 basis points) to the federal funds rate. The discussion focuses on movements in both prices and real investment quantities. Together, they tell us how market conditions in each of the industries comprising PFI react to a policy innovation. Knowledge of both output and relative price dynamics also helps policymakers obtain a more detailed account of the monetary transmission mechanism.

Fig. 2 plots the responses of output and the price level in each sector to a negative funds rate innovation. The solid lines are the response functions for total private fixed investment, PFI_t, and its corresponding price index, Q_t. Both variables belong to the macro-equation block of (1) and are assumed to be unaffected by policy in the initial period. The dashed lines represent the unweighted average of all sectoral price and quantity responses. Their proximity to PFI_t and Q_t suggests that the specific breakdown of fixed investment into its disaggregate components (e.g., the percentage shares reported in Table A) does not have a major impact on the behavior of aggregate prices and quantities following a monetary shock.

Our estimates point to considerable variation in the way industries respond to a policy expansion. Differences emerge not only in the magnitude of the adjustment paths, but also in the direction. Regarding investment quantities, we find that a substantial portion (31 percent) respond negatively four quarters after the shock. In the majority of cases, however, the real effects are positive, and as a result, the unweighted mean response across all 64 industries at the one-year mark is 0.90 percent. Results also show most of the disaggregate quantities taking on the familiar hump-shaped profile seen in the aggregate data. Despite these similarities, we observe significant heterogeneity in the amplitude of sectoral responses. About half peak between 0 and 2 percent while another third reach highs of 3 to 6 percent. The real effects of monetary policy are therefore robust in some capital-producing industries but relatively weak in others. This finding endorses the view that the strength of the transmission mechanism varies from one investment-goods sector to another.

By comparison, there is less cross-sectional heterogeneity in the responses of investment prices. For the first few quarters after a shock, most PFI prices are not far from their baseline values. Estimates reveal that it takes one year for the average price level to start rising on a consistent basis. Over a period of four years, however, all but two of the industries experience some inflation. A majority (two-thirds) sustain anywhere from 0.5 to 1.5 percent.

Table 1 reports summary statistics on the distribution of industry responses one, two, three, and four years after the occurrence of a policy shock. Looking across the 64 categories of private fixed investment (first panel) we see that the dispersion in quantities, as measured by standard deviation, is greater than the dispersion in prices at each horizon. The spread of output responses reaches its highest point about eight quarters after the shock, with half of all industries having increased anywhere from 1.55 to 5.46 percent. After the two-year mark, the distribution of output tends to narrow. Price dispersion, on the other hand, is smaller and increases gradually for the first few years. The standard deviation is only 0.36 percent one year after the shock but rises to 0.77 percent by the end of year four. It is also interesting to note that while the distribution of responses continually shifts towards higher average prices, the variance of that distribution levels off three years after the shock.

Whether price and quantity dispersion is a compelling feature of the data depends to some extent on the significance of the estimates displayed in Fig. 2. To assess significance, we follow Balke and Wynne (2007) by recording the fraction of disaggregate responses that are statistically different from zero at the 10 percent level. A response is considered significant if at least 90 percent of the simulated responses, obtained by sampling from the normal distribution described in footnote 14, are either strictly positive or strictly negative. The results are illustrated in Fig. 3. At horizons of two quarters or less, the fraction of statistically significant output responses never exceeds 25 percent. The proportion increases to around 60 percent seven quarters after the shock and reverts back to 20 percent by the four-year mark. Regarding PFI prices, barely 14 percent are significant one quarter after the policy shock, but over 50 percent are significant six quarters later. By the end of the fourth year, as many as 80 percent of industry prices are statistically different from pre-shock levels.

That a large share of disaggregate responses are significant bolsters the argument made by some that monetary nonneutralities are present in the capital-goods sector of the US economy.[15] Should one's goal be to identify the underlying sources of nonneutrality, the results of our VAR analysis could in principle be used to evaluate the likelihood of alternative models (e.g., price rigidity, imperfect information, limited participation). Here our objective is simply to characterize the behavior of investment in response to unanticipated monetary policy, and as such, the reaction of PFI quantities make two things clear: monetary shocks have nontrivial effects on real investment spending in the short run, and the intensity of these effects vary greatly across industries. Thus policy appears to have important distributional effects which, according to economic theory, can only occur if accompanied by movements in *relative* investment prices. Our findings are consistent with the notion that monetary nonneutralities are linked to relative price changes since both the mean and variance of the cross-sectional distribution of PFI prices increase in the aftermath of a policy shock.

Estimates from our structural VAR show that prices and quantities generally increase in the years following an unexpected drop in the funds rate. Yet the same estimates also

[15]Ghossoub and Reed (2015) develop a version of a monetary growth model to show that optimal monetary policy depends on conditions in the capital sector.

point to considerable variation across industries in the timing and magnitude of these effects. In some industries output adjusts rapidly, while in others it is the price level that is most affected by policy. A natural question then is whether there might be any pattern or tendency in the way investment prices and quantities interact over time. To answer this question, we follow Boivin *et al.* (2009) and Baumeister *et al.* (2013) by forming scatter plots of the price and quantity responses for all 64 PFI categories one, two, and three years after a policy innovation. The results, along with cross-sectional regression lines, are shown in Fig. 4.

Plots of the price responses against the output responses suggest that there may be some commonality in the way different industries respond to a monetary shock. In particular, we find that industries experiencing the biggest gains in real output tend to be the ones experiencing the smallest growth in prices so that the slope is relatively large in absolute terms. Conversely, price increases are usually higher in sectors where output growth is lower. Our results also show this relationship to be persistent with cross-sectional regression lines that are negatively sloped at each response horizon. Point estimates of these slope coefficients, however, should be interpreted with a great deal of caution. Although they range from -0.45 after one year to -0.17 after three years, none are statistically significant at regular confidence levels. Thus evidence of a consistent inverse relationship between the magnitudes of our price and quantity responses is somewhat limited when looking across all industry components of private fixed investment. In the next section, we examine whether the evidence is any more convincing for sample groups that include only those industries belonging to more narrowly-defined subcategories of PFI.

4.3 Major Components of Fixed Investment

To determine whether conditions across certain industry groups react similarly to a policy innovation, we organize the sectoral price and quantity responses into four major investment subcategories: nonresidential structures, residential structures, durable equipment, and intellectual property products. Of the 64 PFI components included in our sample, the BEA classifies 23 as nonresidential structures, 6 as residential structures, 32 as equipment, and 3 as intellectual property. Fig. 5 sorts our estimated response functions into these four groups, and Fig. 6 plots the fraction within each group that are significant at the 10 percent level.

Looking only at nonresidential structures, we see substantial heterogeneity in the response of disaggregate quantities. The statistics reported in Table 1 (second panel) confirm that four quarters after the shock, roughly half of the responses are still negative, with some falling as much as 3 percent below baseline values. Though most do tend to rise over time, it is clear that the cross-sectional dispersion in quantities persists well beyond the one-year mark. As a result, the unweighted mean response across all 23 industries is basically zero for the first year and tops out at just 0.86 percent by the end of year three. At this point, however, fewer than 25 percent of the individual responses are statistically different from zero as seen in Fig. 6. Thus in the majority of cases, monetary policy appears to have little ability to increase spending on nonresidential structures at normal business cycle frequencies.

The behavior of prices is very different–they typically adjust faster and with greater intensity. The median response eight quarters after the shock is 0.62 percent, compared to 0.19 percent when accounting for all of PFI. Moreover, the standard deviation of prices for nonresidential structures is smaller than the standard deviation for all components of PFI. Taken together, our findings make clear that prices are on average more responsive to monetary shocks than output in markets for nonresidential structures.

Disparities between the adjustment of industry prices and quantities are perhaps even more visible among producers of durable equipment. For this class of investment goods, however, it is output rather than prices that tend to be more elastic. Estimates show that most of the 32 disaggregate quantities peak around eight quarters after the shock. As shown in Table 1 (fourth panel), the median output response at this horizon is almost three times the median response for the nonresidential structures category. Also worth noting here are the large differences in the amplitude of responses across industries. In half of them production is anywhere from 2.31 to 5.46 percent higher than pre-shock levels.

By contrast, the prices of durable equipment are generally slow to adjust. Our findings indicate that two years elapse before average prices respond positively to an unexpected drop in the funds rate. Thus in the short run, expansionary policy can boost real spending across the equipment sector without triggering a substantial rise in average inflation. Despite having only a limited effect on the mean, monetary shocks still generate significant cross-sectional variation in prices. Leaving out computers and peripheral equipment, sectoral price growth four years after a policy shock ranges from -0.18 to 2.37 percent.

We now turn our attention to the residential investment category of PFI, which incidentally has been a leading topic of discussion in recent years due to its role in the financial crisis. The behavior of residential structures is markedly different from nonresidential structures and equipment, both of which display a tendency for either prices or quantities to absorb most of the effects of a policy expansion. The same relationship clearly does not describe markets for residential structures. After an unanticipated drop in the funds rate, prices as well as production volumes tend to move higher. Regarding the latter, estimates reveal that output (excluding construction of dormitories) usually peaks four to five quarters after the shock, and according to Table 1 (third panel), the median response at this horizon is 3.32 percent. The real effects also appear to be relatively short-lived. It takes on average about three years for production to revert to pre-shock levels. With regard to prices, evidence suggests that all but one respond quickly to a monetary shock. The median response exceeds 0.40 percent just one year after the shock and nears one percent by the end of year two.[16]

With only three sectors comprising intellectual property products, we are unable to identify any pattern in the way market conditions respond to a policy innovation. For example,

[16]That prices and quantities of residential structures are sensitive to a policy innovation echoes results obtained by Baumeister *et al.* (2013) for the durables component of personal consumption expenditures.

real production of entertainment, literary, and artistic originals grows by almost one percent for the first year. Production of software and research and development, on the other hand, both decline in the months following a funds rate shock, with the former shrinking as much as 0.54 percent. Meanwhile, the price levels observed in these sectors display significant inertia. Response functions indicate that two years go by before average prices start rising.

4.4 Evidence on Capital Supply Elasticities

That the prices of certain capital goods are more/less responsive to monetary shocks than investment quantities bears some resemblance to results reported in Goolsbee (1998), Hassett and Hubbard (1998), and Edgerton (2010). In all three papers, the authors use data on producers' durable equipment to determine whether tax credits aimed at stimulating investment demand increase real production or simply materialize in the form of higher capital-goods prices. Goolsbee (1998) argues that the real effects are severely limited by the fact that short-run equipment supply curves are inelastic. His argument is based on a series of regressions showing that for most asset types, a 10 percent investment tax credit raises prices by more than 8 percent. By contrast, Hassett and Hubbard (1998) and Edgerton (2010) present regression coefficients that point to much higher capital supply elasticities. They conclude that policy incentives designed to boost investment demand will likely have significant effects on fixed-capital formation with only modest effects on prices.[17]

Since we are examining how the price and quantity of fixed investment reacts to *monetary* rather than *fiscal* stimuli, our estimates can neither confirm nor discredit the findings described above. Given the demand-side nature of the two policies, however, it may be useful to draw some comparisons between the elasticities reported in this literature and those implied by our VAR model. To that end, Table 2 presents short-run output elasticities to

[17] In a simultaneous equations setting, Edgerton (2010) directly estimates the price elasticity of supply for construction, agricultural, and mining and oilfield machinery. His estimates indicate that only 17 percent of the value of tax subsidies would pass through into machinery prices.

a one standard deviation drop in the federal funds rate for each industry represented in the durable equipment category of PFI. We define the short-run elasticity as the maximum point estimate of the impulse response function recorded between six months and two years after the policy innovation.[18] The table also lists the quarter in which the peak effect occurs along with an estimate of the concurrent price elasticity. Information on the responsiveness of both prices and output helps clarify the extent to which upward-sloping capital supply schedules undermine the real effects of expansionary monetary policy.

Results from our VAR show that 25 of 32 industries exhibit positive and significant output elasticities in the short run. The biggest increases take place in sectors that produce heavy machinery (e.g., farm and construction tractors, other agricultural and construction machinery, mining and oilfield machinery, and service industry machinery) or large transportation equipment (e.g., trucks, buses, and truck trailers, autos, ships and boats, and railroad equipment). A negative funds rate innovation boosts real production in these industries anywhere from 1.5 to 6 percent within two years. Yet over the same period, just 8 of 32 industries sustain higher prices, and in only two cases is the increase statistically above zero at a 90 percent confidence level. According to our estimates, a larger share actually experience a significant decline in prices. For example, sectors that produce information processing equipment (e.g., computers, communication, and electro-medical equipment, nonmedical instruments, and office and accounting equipment) see prices falling between 0.2 and 2.5 percent.[19]

The evidence in Table 2 tells a consistent story about markets for durable equipment. Monetary expansions, which increase the demand for fixed investment, lead to significant growth in real quantities with few discernible price increases.[20] These findings are at odds

[18]Transforming the industry variables into natural-log levels means that impulse response estimates can be interpreted as elasticities.

[19]These negative price elasticities may be partly attributable to difficulties in correcting the investment deflators for unmeasured quality improvements. See Goolsbee (1998) for a discussion.

[20]In the traditional cost of capital model of Hall and Jorgenson (1967), demand for capital services grows until the rental price equals the user cost of capital, which is increasing in the interest rate. By reducing interest rates, a monetary expansion should lower user costs and thereby raise the demand for capital services.

with the notion put forth by Goolsbee (1998) that equipment supply curves are inelastic in the short run. Instead, they favor the opposite interpretation suggested by Hassett and Hubbard (1998) and Edgerton (2010) that supply elasticities are large. Under such conditions, the effects of a stimulative demand shock would show up in quantities rather than prices.[21]

While not part of Goolsbee's original analysis, disaggregated data on nonresidential structures is actually more consistent with the view that capital supply curves are relatively inelastic in the short run. Table 3 presents output and price elasticities for each industry comprising the nonresidential structures component of PFI. In sharp contrast to the equipment category, our estimates show a positive and significant price elasticity in 15 of 23 industries. We observe some of the biggest price increases, ranging from 0.6 to 2.1 percent, among producers of petroleum and natural gas wells as well as commercial and health care structures (e.g., offices, medical buildings, multimerchandise shopping, restaurants, and warehouses). In the eight industries where price elasticities are either negative or insignificant, growth in real production is not statistically different from zero. Meanwhile, in only 8 of 23 industries is there compelling evidence of a short-run output effect, a much smaller portion than what is found across the equipment-goods sector of the economy.

It is worth noting here that our results may give researchers some insight on the nature of adjustment costs within the capital goods sector. For example, the absence of a strong quantity response in the nonresidential structures category may be due to higher adjustment costs associated with "lumpy" investment goods such as office buildings and manufacturing establishments. Non-lumpy investment items such as computers and peripheral equipment, which display more robust output effects in the data, are less likely to be constrained by these kinds of frictions. Viewed in this context, our findings complement the literature on the role of adjustment costs for investment and business cycle activity.[22]

[21]Investment in durable equipment and machinery has also been a key factor in post-war growth across industrialized and developing economies (e.g., De Long and Summers, 1991, 1992, 1993; Jones, 1994).

[22]Caballero, Engel, and Haltiwanger (1995) report significant variation in the long-run elasticities of in-

5 Concluding Remarks

We employ disaggregate data spanning all industry categories of private fixed investment to examine how capital-goods prices and real investment quantities respond to an aggregate monetary shock. Examining the full spectrum of industries together reveals that while most, but not all, experience growth in real output, there is considerable heterogeneity in the timing and magnitude of the effects. Moreover, the dispersion in quantities is accompanied by broad cross-sectional variation in the response of investment prices. One interpretation of this finding is that monetary nonneutralities are pervasive in markets for fixed capital.

In addition to distributional effects, the data exposes certain patterns in the way market conditions within more narrowly-defined asset classes react to a policy disturbance. Across markets for durable equipment, output responses tend to be elastic while price responses tend to be sluggish. Among producers of nonresidential structures, it is prices rather than quantities that are frequently more responsive. Suppliers of residential structures see both variables respond swiftly to a policy shock. These findings along with others documented in the paper contribute to recent efforts that shed light on the monetary transmission mechanism using information drawn from sectoral price and output data.

One interpretation of the apparent heterogeneity in our disaggregate response functions is that the strength of the monetary transmission mechanism is not uniform across capital-producing industries. The implication then is that there will be significant cross-sectional variability in the power of monetary policy to stimulate different types of investment activity. In particular, our estimates suggest that the expansionary effects of policy are greatest when spending on either durable equipment or housing is relatively weak. If, however, activity in nonresidential structures is flagging, the real effects of policy are probably going to be small.

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vestment with respect to costs of capital across industries. Cooper and Haltiwanger (2006) discuss several industry case studies of investment adjustment costs.

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Appendix

Table A
Components of private fixed investment in 2007

	Component	Aggregation level *1*	*2*	*3*	*4*	*5*	*6*
1.	Nonresidential	73.614					
2.	Structures		19.049				
3.	Commercial & health care			6.967			
4.	Office[1]				2.371	2.371	2.371
5.	Health care				1.535		
6.	Hospitals & special care					1.191	
7.	Hospitals						1.058
8.	Special care						0.133
9.	Medical buildings					0.344	0.344
10.	Multimerchandise shopping				1.332	1.332	1.332
11.	Food & beverage establishments				0.308	0.308	0.308
12.	Warehouses				0.648	0.648	0.648
13.	Other commercial[2]				0.773	0.773	0.773
14.	Manufacturing			1.542	1.542	1.542	1.542
15.	Power & communication			3.129			
16.	Power				2.075		
17.	Electric					1.590	1.590
18.	Other power					0.485	0.485
19.	Communication				1.054	1.054	1.054
20.	Mining exploration, shafts, & wells			3.918			
21.	Petroleum & natural gas				3.636	3.636	3.636
22.	Mining				0.282	0.282	0.282
23.	Other structures			3.493			
24.	Religious				0.288	0.288	0.288
25.	Educational & vocational				0.657	0.657	0.657
26.	Lodging				1.304	1.304	1.304
27.	Amusement & recreation				0.469	0.469	0.469
28.	Transportation				0.345		
29.	Air					0.038	0.038
30.	Land[3]					0.307	0.307
31.	Farm				0.241	0.241	0.241
32.	Other[4]				0.170	0.170	0.170
33.	Brokers' commissions on sale of structures				0.130	0.130	0.130
34.	Net purchases of used structures				−0.112	−0.112	−0.112
35.	Equipment		33.948				
36.	Information processing equipment			11.623			
37.	Computers and peripheral equipment				3.362	3.362	3.362
38.	Communication equipment				4.069	4.069	4.069
39.	Medical equipment & instruments				2.772		
40.	Electro-medical equipment					1.396	1.396
41.	Medical instruments					1.376	1.376
42.	Nonmedical instruments				0.999	0.999	0.999
43.	Photocopy & related equipment				0.251	0.251	0.251
44.	Office & accounting equipment				0.169	0.169	0.169

Notes: The table reports nominal spending on each component as a percentage share of total private fixed investment (PFI) in 2007. Shares are listed for every level of aggregation in the underlying NIPA series. The highest aggregation level (*1*) has only two components while the lowest (*6*) breaks PFI into 67 components. At each level, the disaggregate shares sum to 100.

Table A
Continued

	Component	1	2	3	4	5	6
				Aggregation level			
45.	Industrial equipment			7.439			
46.	Fabricated metal products				0.758	0.758	0.758
47.	Engines & turbines				0.437		
48.	Steam engines					0.295	0.295
49.	Internal combustion engines					0.142	0.142
50.	Metalworking machinery				1.091	1.091	1.091
51.	Special industry machinery, n.e.c.[6]				1.346	1.346	1.346
52.	General industrial & materials handling				2.554	2.554	2.554
53.	Electric transmission & distribution apparatus				1.253	1.253	1.253
54.	Transportation equipment			7.237			
55.	Trucks, buses, & truck trailers				3.709		
56.	Light trucks, including utility vehicles[7]					2.531	2.531
57.	Other trucks, buses, & truck trailers[7]					1.178	1.178
58.	Autos[7]				1.866	1.866	1.866
59.	Aircraft				1.085	1.085	1.085
60.	Ships & boats				0.229	0.229	0.229
61.	Railroad equipment				0.349	0.349	0.349
62.	Other equipment			8.116			
63.	Furniture & fixtures				1.614		
64.	Household furniture					0.107	0.107
65.	Other furniture					1.507	1.507
66.	Agricultural machinery				0.888		
67.	Farm tractors					0.373	0.373
68.	Other agricultural machinery					0.515	0.515
69.	Construction machinery				1.380		
70.	Construction tractors					0.108	0.108
71.	Other construction machinery					1.272	1.272
72.	Mining & oilfield machinery				0.693	0.693	0.693
73.	Service industry machinery				1.015	1.015	1.015
74.	Electrical equipment, n.e.c.				0.202		
75.	Household appliances					0.032	0.032
76.	Miscellaneous electrical					0.170	0.170
77.	Other				2.325	2.325	2.325
78.	Less: Sale of equipment scrap, excluding autos			0.467	0.467	0.467	0.467
79.	Intellectual property products		20.617				
80.	Software[8]			9.359	9.359	9.359	9.359
81.	Research & development[9]			8.560	8.560	8.560	8.560
82.	Entertainment, literary, & artistic originals			2.698	2.698	2.698	2.698
83.	Residential	26.386					
84.	Structures		26.007				
85.	Permanent site			13.567			
86.	Single-family structures				11.691	11.691	11.691
87.	Multifamily structures				1.876	1.876	1.876
88.	Other structures			12.440			
89.	Manufactured homes				0.360	0.360	0.360
90.	Dormitories				0.111	0.111	0.111
91.	Improvements				6.577	6.577	6.577
92.	Brokers' commissions & other transfer costs[10]				5.544	5.544	5.544
93.	Net purchases of used structures				−0.153	−0.153	−0.153
94.	Equipment		0.379	0.379	0.379	0.379	0.379

Legend/Footnotes

1. Consists of office buildings, except those constructed at manufacturing sites and those constructed by power utilities for their own use. Includes all financial buildings.

2. Includes buildings and structures used by the retail, wholesale and selected service industries. Consists of auto dealerships, garages, service stations, drug stores, restaurants, mobile structures, and other structures used for commercial purposes. Bus or truck garages are included in transportation.

3. Consists primarily of railroads.

4. Includes water supply, sewage and waste disposal, public safety, highway and street, and conservation and development.

5. Consists of brokers' commissions on the sale of residential structures and adjoining land, title insurance, state and local documentary stamp taxes, attorney fees, title abstract and escrow fees, and fees for surveys and engineering services.

6. n.e.c. Not elsewhere classified.

7. Includes net purchases of used vehicles

8. Excludes software "embedded," or bundled, in computers and other equipment.

9. Research and development investment excludes expenditures for software development. Software development expenditures are included in software investment on line 80.

10. Consists of brokers' commissions on the sale of residential structures and adjoining land, title insurance, state and local documentary stamp taxes, attorney fees, title abstract and escrow fees, and fees for surveys and engineering services.

Table 1
Summary statistics for the distribution of PFI price and quantity responses

	Quantity responses (in percent)				Price responses (in percent)			
	1 year	2 years	3 years	4 years	1 year	2 years	3 years	4 years
I. *Private fixed investment* (64)								
average	0.90	1.59	1.40	1.02	−0.07	0.28	0.67	0.97
median	0.88	1.55	1.44	0.92	−0.03	0.19	0.65	1.01
minimum	−3.86	−7.03	−4.31	−2.38	−1.96	−2.43	−2.49	−2.30
maximum	5.15	5.46	5.49	6.05	0.53	2.10	3.50	4.20
standard deviation	1.76	2.00	1.71	1.60	0.36	0.61	0.76	0.77
II. *Nonresidential structures* (23)								
average	−0.02	0.76	0.86	0.62	0.12	0.62	1.18	1.45
median	0.03	0.80	1.05	0.49	0.15	0.62	1.03	1.36
minimum	−3.11	−2.45	−2.76	−2.22	−0.33	0.08	0.61	0.85
maximum	1.61	3.18	3.40	5.00	0.51	2.10	3.50	4.20
standard deviation	1.29	1.47	1.41	1.47	0.17	0.36	0.54	0.61
III. *Residential structures* (6)								
average	2.11	0.95	−0.22	−0.75	0.33	0.85	1.18	1.37
median	3.32	2.05	0.24	−0.83	0.40	0.93	1.24	1.45
minimum	−3.86	−7.03	−4.31	−2.38	−0.03	0.41	0.71	0.90
maximum	5.15	4.05	2.39	1.25	0.53	1.12	1.46	1.66
standard deviation	2.94	3.67	2.10	1.26	0.21	0.26	0.28	0.29
IV. *Equipment* (32)								
average	1.40	2.44	2.22	1.71	−0.27	−0.05	0.29	0.60
median	1.28	2.31	1.93	1.23	−0.20	−0.04	0.31	0.61
minimum	−1.32	−1.09	−0.63	−0.60	−1.96	−2.43	−2.49	−2.30
maximum	4.74	5.46	5.49	6.05	0.17	2.03	2.86	2.37
standard deviation	1.46	1.56	1.44	1.43	0.37	0.61	0.75	0.72
V. *Intellectual property* (3)								
average	0.14	0.15	0.06	0.14	−0.16	−0.03	0.20	0.42
median	−0.01	0.13	0.05	0.17	−0.14	−0.01	0.26	0.51
minimum	−0.54	−0.23	−0.18	−0.13	−0.24	−0.17	−0.09	0.05
maximum	0.98	0.54	0.31	0.38	−0.09	0.08	0.43	0.69
standard deviation	0.63	0.32	0.20	0.21	0.06	0.10	0.22	0.27

Notes: The table reports summary statistics describing the cross-sectional distribution of PFI price and quantity responses at selected horizons to a one standard deviation (71 basis point) drop in the federal funds rate. Sample moments are computed across the full set of industries comprising private fixed investment (64 series) along with subgroups comprising nonresidential structures (23 series), residential structures (6 series), equipment (32 series), and intellectual property products (3 series).

Table 2
Output and price elasticities for durable equipment

Industry	Output elasticity		Period	Price elasticity	
Computers and peripheral equipment	2.814	[0.51, 5.37]	8	−2.431	[−3.73, −1.35]
Communication equipment	1.809	[0.60, 3.14]	8	−0.450	[−0.88, −0.06]
Electro-medical equipment	2.788	[1.01, 4.79]	6	−0.492	[−1.02, −0.11]
Medical instruments	0.391	[−0.31, 1.07]	3	−0.128	[−0.29, 0.03]
Nonmedical instruments	1.460	[0.54, 2.38]	8	−0.209	[−0.42, −0.01]
Photocopy & related equipment	0.882	[−1.83, 3.69]	6	−0.493	[−1.09, 0.04]
Office & accounting equipment	4.639	[2.25, 7.32]	8	−0.263	[−0.53, −0.01]
Fabricated metal products	0.844	[−0.30, 2.00]	8	0.398	[−0.03, 0.86]
Steam engines	−0.153	[−3.30, 3.03]	2	−0.122	[−0.47, 0.23]
Internal combustion engines	3.303	[2.12, 4.62]	8	−0.034	[−0.43, 0.34]
Metalworking machinery	1.654	[−0.11, 3.29]	8	0.064	[−0.30, 0.43]
Special industry machinery, n.e.c.	0.824	[−0.25, 1.92]	7	−0.010	[−0.39, 0.36]
General industrial & materials handling	2.179	[1.17, 3.21]	8	−0.046	[−0.34, 0.25]
Electrical transmission & distribution apparatus	1.553	[0.71, 2.41]	8	−0.254	[−0.61, 0.07]
Trucks, buses, & truck trailers	4.212	[2.50, 6.03]	6	−0.071	[−0.35, 0.20]
Autos	1.807	[0.70, 2.99]	5	−0.038	[−0.44, 0.35]
Aircraft	1.895	[−0.98, 4.99]	8	0.258	[−0.03, 0.56]
Ships & boats	4.511	[1.85, 7.38]	8	0.198	[−0.06, 0.44]
Railroad equipment	3.443	[0.42, 6.75]	8	0.625	[0.06, 1.19]
Household furniture	1.657	[0.07, 3.28]	6	−0.059	[−0.26, 0.14]
Other furniture	1.600	[0.65, 2.60]	6	−0.055	[−0.35, 0.21]
Farm tractors	4.614	[2.66, 6.62]	5	−0.397	[−0.68, −0.12]
Other agricultural machinery	2.604	[1.08, 4.19]	8	−0.045	[−0.37, 0.26]
Construction tractors	5.932	[2.76, 9.20]	6	−0.040	[−0.43, 0.33]
Other construction machinery	4.383	[2.41, 6.43]	7	0.079	[−0.29, 0.44]
Mining & oilfield machinery	3.842	[0.02, 7.97]	8	0.175	[−0.40, 0.74]
Service industry machinery	1.560	[0.72, 2.46]	7	−0.188	[−0.42, 0.01]
Household appliances	3.432	[1.97, 4.99]	6	−0.302	[−0.59, −0.03]
Miscellaneous electrical	3.562	[1.94, 5.37]	8	−0.024	[−0.31, 0.25]
Other	2.447	[1.58, 3.42]	8	−0.362	[−0.69, −0.07]
Less: Sale of equipment scrap, excluding autos	5.461	[3.09, 8.06]	8	2.034	[0.00, 4.07]
Residential equipment	1.772	[0.99, 2.64]	6	−0.306	[−0.50, −0.12]

Notes: The table reports output and price elasticities to a 71 basis point drop in the federal funds rate for each industry in the durable equipment category of PFI (ordered as they appear in Table A). Output elasticity is the maximum point estimate of the sectoral response function recorded between six months and two years after the funds rate shock. Period is the number of quarters after the shock in which the peak effect occurs. Price elasticity is the estimate of the sectoral price response function that prevails during the quarter identified in the preceding column. Bracketed numbers are 90 percent confidence intervals.

Table 3
Output and price elasticities for nonresidential structures

Industry	Output elasticity		Period	Price elasticity	
Office	0.291	$[-1.58, 2.06]$	8	0.658	$[0.34, 1.00]$
Hospitals	0.232	$[-0.74, 1.22]$	2	0.016	$[-0.09, 0.11]$
Special care	−0.258	$[-1.38, 0.86]$	2	0.069	$[-0.04, 0.18]$
Medical buildings	0.517	$[-1.54, 2.54]$	8	0.662	$[0.34, 1.00]$
Multimerchandise shopping	3.184	$[1.28, 5.36]$	8	0.678	$[0.34, 1.04]$
Food & beverage establishments	2.269	$[0.55, 4.13]$	8	0.646	$[0.34, 0.96]$
Warehouses	2.236	$[0.41, 4.19]$	8	0.572	$[0.29, 0.88]$
Other commercial	2.626	$[0.99, 4.41]$	8	0.629	$[0.33, 0.94]$
Manufacturing	0.429	$[-1.80, 2.55]$	8	0.582	$[0.31, 0.87]$
Electric	−0.289	$[-2.03, 1.45]$	3	−0.085	$[-0.31, 0.14]$
Other power	−1.278	$[-2.60, 0.04]$	2	0.053	$[-0.19, 0.29]$
Communication	1.417	$[0.02, 2.89]$	8	0.667	$[0.25, 1.08]$
Petroleum & natural gas	1.095	$[-0.78, 3.04]$	8	2.097	$[0.62, 3.71]$
Mining	2.596	$[0.48, 4.84]$	7	0.484	$[0.21, 0.78]$
Religious	1.398	$[0.14, 2.69]$	8	0.630	$[0.33, 0.97]$
Educational & vocational	0.995	$[-065, 2.65]$	4	0.121	$[-0.07, 0.32]$
Lodging	−0.528	$[-4.67, 3.21]$	8	0.581	$[0.20, 1.00]$
Amusement & recreation	0.489	$[-1.25, 2.20]$	8	0.551	$[0.22, 0.89]$
Air	0.277	$[-1.61, 2.14]$	7	0.427	$[0.16, 0.71]$
Land	1.493	$[-0.03, 3.07]$	6	0.105	$[-0.38, 0.59]$
Farm	2.520	$[0.16, 4.97]$	8	0.767	$[0.40, 1.19]$
Other	−0.382	$[-2.91, 2.12]$	8	0.078	$[-0.44, 0.56]$
Brokers' commissions on sale of structures	1.484	$[-0.18, 3.19]$	8	0.300	$[-0.01, 0.63]$

Notes: The table reports output and price elasticities to a 71 basis point drop in the federal funds rate for each industry in the nonresidential structures category of PFI (ordered as they appear in Table A). Output elasticity is the maximum point estimate of the sectoral response function recorded between six months and two years after the funds rate shock. Period is the number of quarters after the shock in which the peak effect occurs. Price elasticity is the estimate of the sectoral price response function that prevails during the quarter identified in the preceding column. Bracketed numbers are 90 percent confidence intervals.

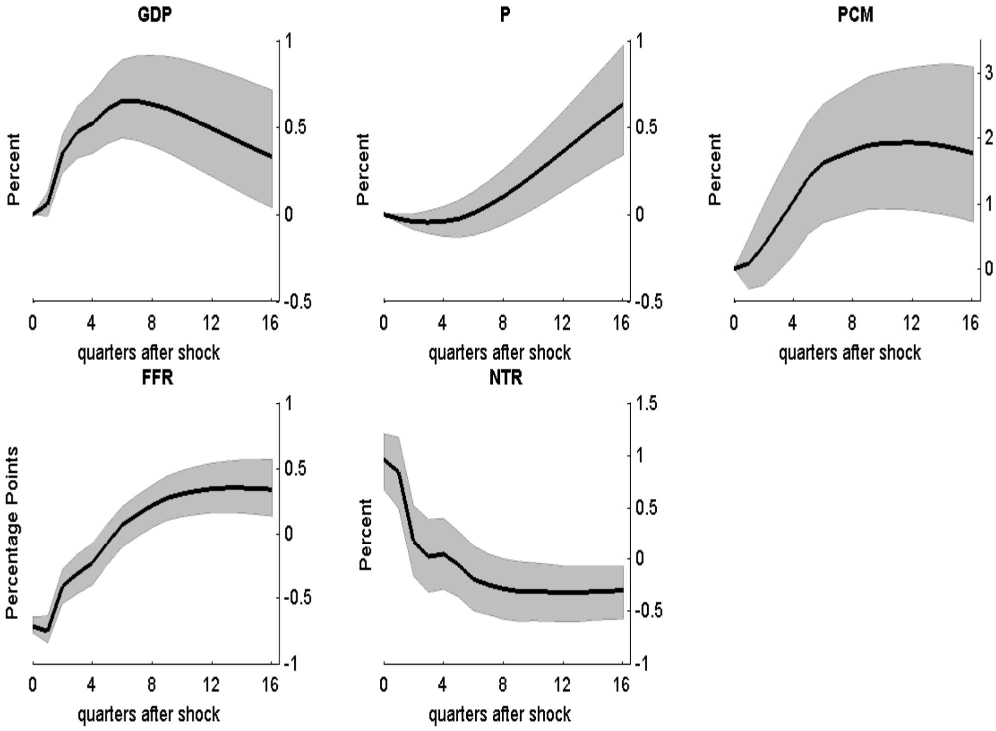

Fig. 1. Estimated impulse responses to a one standard deviation (71 basis point) drop in the federal funds rate are graphed for the following aggregate macroeconomic variables: **GDP** - real GDP, **P** - GDP chain-type price index, **PCM** - ratio of crude materials to finished goods in the Producer Price Index, **FFR** - effective federal funds rate, **NTR** - ratio of nonborrowed to total reserves. The shaded regions correspond to 90 percent confidence bands.

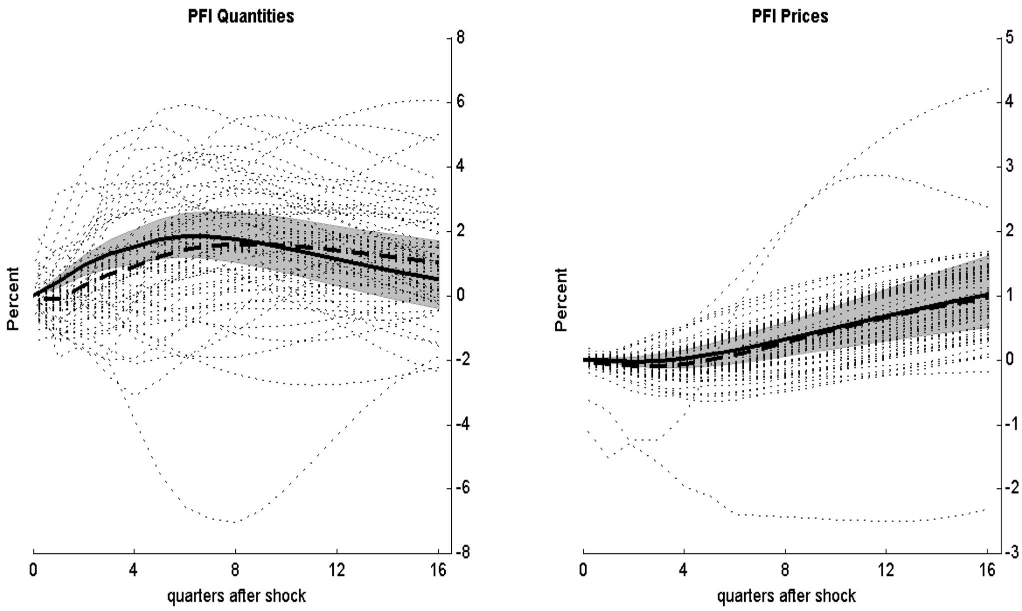

Fig. 2. Estimated impulse responses to a one standard deviation (71 basis point) drop in the federal funds rate are graphed for sectoral PFI quantities (left panel) and PFI prices (right panel). Thick dashed lines are unweighted average responses across all sectors. Thick solid lines are the responses of the aggregate PFI quantity and price index. The shaded regions are 90 percent confidence bands for the aggregate response functions.

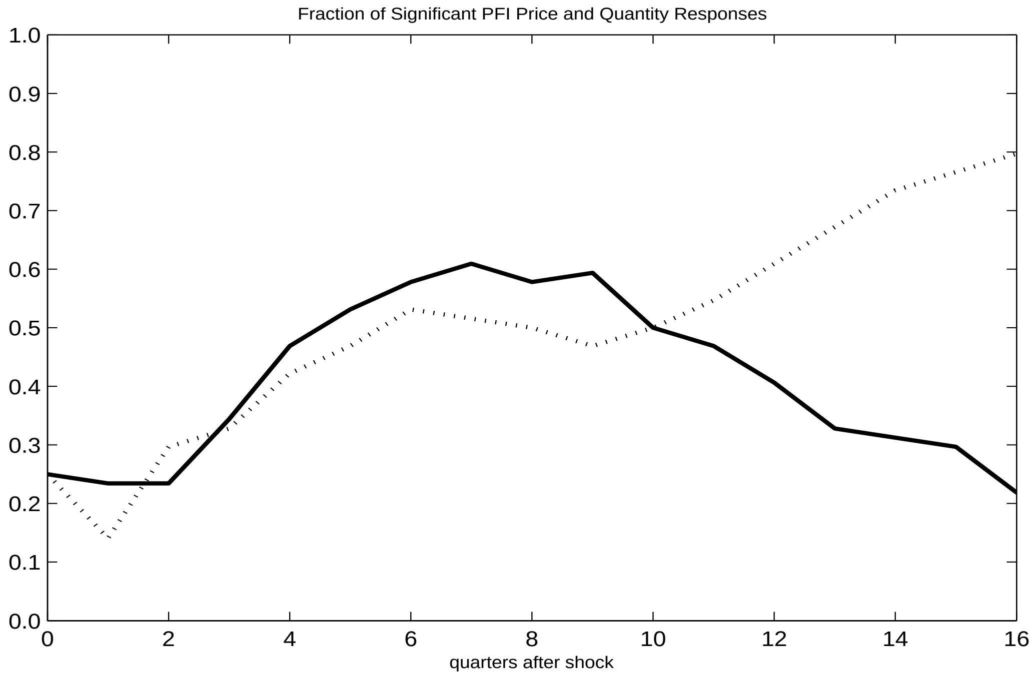

Fig. 3. The fraction of all PFI prices (dotted line) and quantities (solid line) in which the response to a monetary policy shock is significantly different from zero at a 90 percent confidence level are graphed for horizons of up to four years. The shock is an unexpected decrease of 71 basis points to the federal funds rate.

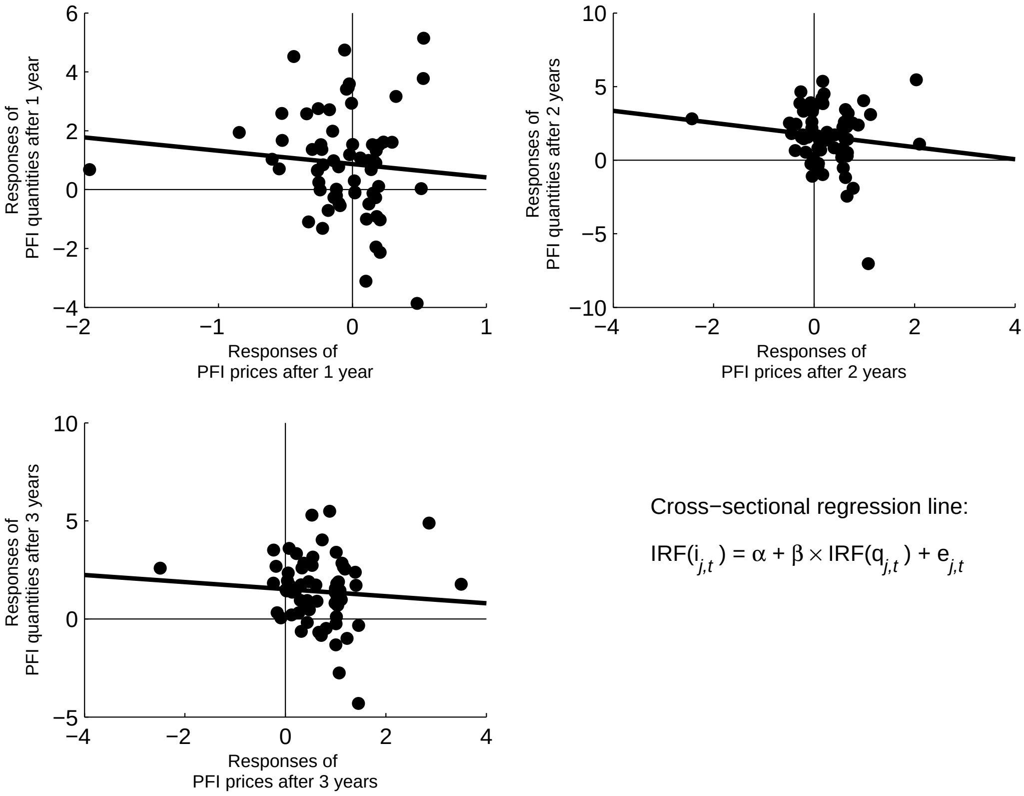

Fig. 4. All 64 pairs of sectoral PFI price and quantity responses to an identified monetary policy shock are depicted in a scatter plot at one, two, and three year horizons. The shock is an unexpected decrease of 71 basis points to the federal funds rate. The solid line represents the cross-sectional regression line.

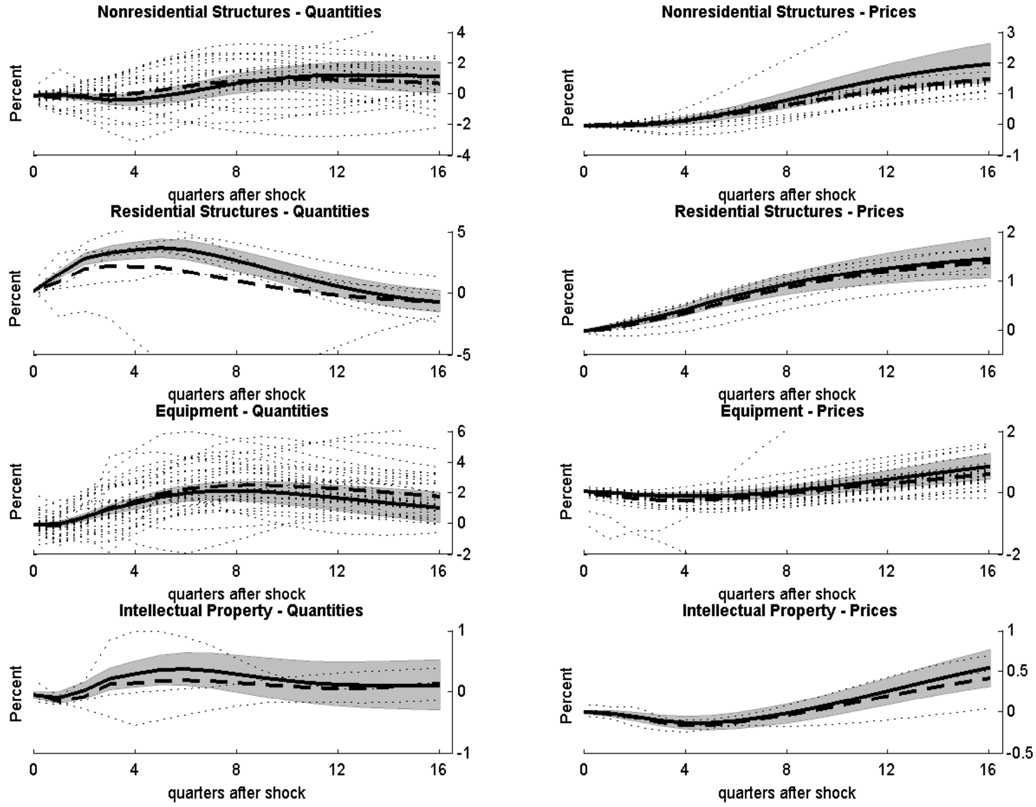

Fig. 5. Estimated impulse responses to a one standard deviation (71 basis point) drop in the federal funds rate for all PFI quantities (left panel) and prices (right panel) are sorted by nonresidential structures, residential structures, durable equipment, and intellectual property products. Thick dashed lines are unweighted average responses across all industries within a given category. Thick solid lines are the responses of the aggregate quantity and price index (aggregation level 2 in Table A).

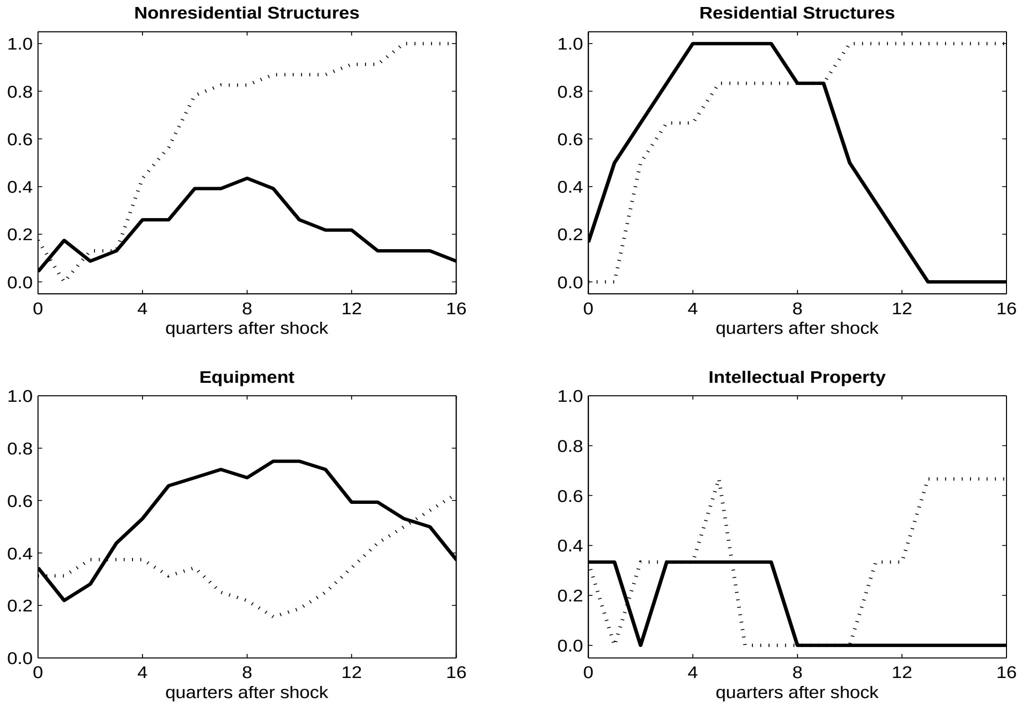

Fig. 6. For each of the four major components of PFI–nonresidential structures, residential structures, durable equipment, and intellectual property products–the fraction of prices (dotted lines) and quantities (solid lines) in which the response to a monetary policy shock is significantly different from zero at a 90 percent confidence level are graphed for horizons of up to four years. The shock is an unexpected decrease of 71 basis points to the federal funds rate.