Customer Markets and Financial Frictions: Implications for Inflation Dynamics

Simon Gilchrist
Egon Zakrajšek

I.   Introduction

What accounts for the apparent resilience of producer, as well as consumer, prices in the face of significant and long-lasting economic slack? This question has been thrust to the forefront of macroeconomic research by the extraordinary events surrounding the Great Recession and continues to puzzle economists and monetary policy makers alike. To put things into perspective, the Congressional Budget Office estimates the level of U.S. real GDP was still almost 2.5 percent below its estimated potential as of the first quarter of 2015, nearly six years after the official end of the recession. Over that period, however, core producer prices—measured by the finished goods producer price index (PPI), excluding food and energy—rose at an average annual rate of nearly 2 percent. Moreover, core producer prices increased at an average annual rate of more than 3 percent during the downturn, a period that saw the largest decline in output since the Great Depression.[1]

The absence of significant deflationary pressures in response to the emergence of such a large and persistent degree of resource underutilization has proven difficult to reconcile with the canonical Phillips curve-type relationships that lie at the heart of the New Keynesian paradigm (see Hall 2011; King and Watson 2012). Recent work by

Gilchrist, Schoenle, Sim and Zakrajšek (2015b) (GSSZ hereafter) argues that the financial crisis that caused the most recent recession also put in play forces that quelled the downward pressure on inflation one would normally expect in response to such a large decline in output. Using a novel data set of item-level price data underlying the PPI and matched to balance sheet information on firms, GSSZ show that financially weak firms significantly increased prices in 2008, a period marked by significant dislocations in the functioning of credit markets and a sharp contraction in output. In a move consistent with standard pricing models, by contrast, financially strong firms lowered prices during this period.

To rationalize these empirical results, GSSZ extend the insights of Gottfries (1991) and Chevalier and Scharfstein (1996) to build a dynamic stochastic general equilibrium (DSGE) model, in which firms operating in customer markets also face liquidity constraints, resulting from the presence of capital market imperfections. In a customer markets model, firms view their customer base as an asset, in which one can invest by reducing prices. Frictions in financial markets, however, cause firms to discount the future more heavily and hence impede investment activity. As a result, financially constrained firms have an incentive to raise prices relative to their unconstrained competitors during economic downturns—by doing so, they maintain current cash flows at the expense of future market share. Consistent with the empirical evidence, their theoretical framework implies a significant attenuation of the response of inflation to contractionary demand and adverse financial shocks, compared with the model that features only customer markets and no financial market distortions.

This paper provides further exploration of the role financial frictions play in the determination of cyclical inflation dynamics. On the empirical side, we provide new evidence on how changes in financial conditions affect producer prices at the level of narrowly defined industries. The rich cross-sectional dimension of these data allows us to analyze the extent to which the response of industry-level producer prices to aggregate financial conditions varies across industries, according to the likelihood that firms in a given industry face financial constraints and, hence, may be particularly sensitive to changes in financial conditions. In addition, these data are available since the

early 1970s and thus provide an important robustness check on the results of GSSZ, who focus exclusively on firms' pricing behavior during the Great Recession. We also exploit the combination of item- and firm-level heterogeneity in the data constructed by GSSZ to provide additional evidence on how firms' financial conditions affected their pricing behavior during the recent crisis.

Our new empirical findings strongly confirm the hypothesis that changes in financial conditions significantly influence the dynamics of producer prices over a business cycle. According to our results, prices in industries in which firms rely more heavily on external finance and thus face a higher likelihood of financing constraints decline noticeably less in response to economic downturns associated with a significant tightening of financial conditions. At the firm level, we provide complementary evidence to GSSZ, showing that firms' pre-crisis internal liquidity position had an important effect on their price-setting behavior in 2008, the nadir of the crisis. Specifically, we use quantile regression analysis to show that a weak balance sheet position in 2006 strongly influenced the likelihood that a firm raised its prices above the industry average during the crisis.

On the theoretical side, we focus on the two-sector extension of the basic model developed by GSSZ and explore the robustness of its conclusions to alternative calibrations. We also highlight a set of novel results regarding the ability of monetary authorities to devise a robust policy rule aimed at achieving the twin goals of output and inflation stabilization. In contrast to GSSZ, who are concerned primarily with inflation dynamics in periods of severe financial stress, we consider an environment with a much more modest degree of financial frictions. In effect, we use this novel framework to analyze the "run-of-the-mill" dynamics of inflation—and other macroeconomic aggregates—in response to different shocks. In addition to calibrating the model to a significantly smaller degree of financial distortions, we also assume substantially smaller costs of changing nominal output prices, a choice that allows us to highlight the fact that nominal price rigidities are not the main driving force of this framework.

Consistent with the results reported by GSSZ, the interaction of customer markets and financial frictions implies a significant attenuation of the response of inflation to demand shocks. In response to

financial disturbances, however, inflation and output move in opposite directions, as financially constrained firms seek to raise prices and maintain current cash flows in the face of deteriorating financial conditions. Our simulations thus show that differences in access to external finance can help rationalize the documented cross-sectional patterns in producer prices.

As emphasized by GSSZ, the combination of customer markets and financial frictions can fundamentally alter inflation and output dynamics relative to the standard New Keynesian framework. This can lead to a significant dilemma for monetary policy makers, whose aim is to stabilize both inflation and output fluctuations. In an effort to begin to understand the monetary policy implications of this mechanism, our last set of simulations explores the effects of different interest-rate rules on economic outcomes. Within this policy framework, we find that strong inflation targeting may be beneficial if the economy is perturbed by a demand shock. However, a more "dovish" policy that puts more weight on output stabilization and significantly less weight on its inflation objective substantially mitigates the real effects of financial shocks, with virtually no attendant increase in inflation.

As this symposium attests, the unorthodox behavior of inflation during the Great Recession and its aftermath is far from being well understood. The two most widely cited explanations advanced by the profession have centered on the notion that economic agents have well-anchored inflation expectations (Bernanke 2010; Yellen 2013) or on a typical labor market dynamics (Stock and Watson 2013; Gordon 2013; Krueger, Cramer and Cho 2014). The first explanation argues that the Federal Reserve's credibility has led businesses and households to essentially discount inflation outcomes that fall outside the narrow range bracketing the Federal Open Market Committee's inflation target of 2 percent; this anchoring of agents' expectations has—through the standard expectational effects—prevented actual inflation from falling significantly below that level. The second argues that the relevant measure of economic slack in empirical Phillips curves is not the overall unemployment rate, but rather the short-term unemployment rate.[2] Compared with the former, this

latter indicator of slack increased notably less during the Great Recession and has also returned more quickly to its pre-recession levels, thus providing substantially less deflationary impetus.[3]

We view the interaction of customer markets and financial frictions as a complementary mechanism to these two explanations which, though not quite settling the case of "missing deflation," nevertheless appear to be broadly supported by the data (see Ball and Mazumder 2014).[4] The role of financial frictions in helping to explain inflation dynamics during the crisis—without relying on large exogenous markup shocks—has also been underscored by the recent New Keynesian literature (see Del Negro, Giannoni and Schorfheide 2015; Christiano, Eichenbaum and Trabandt 2015).[5] However, this literature is unable to account for the differences in the actual pricing behavior of firms in different financial positions during the Great Recession and, moreover, tends to rely on the degree of nominal price rigidities that is considerably greater than that implied by the available empirical evidence (see Bils and Klenow 2004; Nakamura and Steinsson 2008).

The remainder of the paper is organized along the following lines. Section II presents some stylized facts about the behavior of aggregate producer prices. The first part of Section III contains our new analysis of the industry-level pricing dynamics, while the second part zeroes in on the financial crisis using the detailed item-level prices underlying the PPI. Section IV provides an intuitive description of the GSSZ model and highlights its main mechanisms. Model simulations emphasizing the main macroeconomic implications of financial frictions and customer markets are presented in Section V. Section VI concludes.

II.   Some Stylized Facts

Chart 1 shows the behavior of prices received by U.S. producers for their output, measured by the 12-month percent change (constructed as 100 times the 12-month log difference) in the overall finished goods PPI and by the corresponding change in the core finished goods PPI. Several distinct inflation regimes are evident in the data. The high inflation period of the 1970s was influenced importantly by the Federal Reserve's overly optimistic view of the natural rate of

Chart 1
Producer Prices, 1968-2014
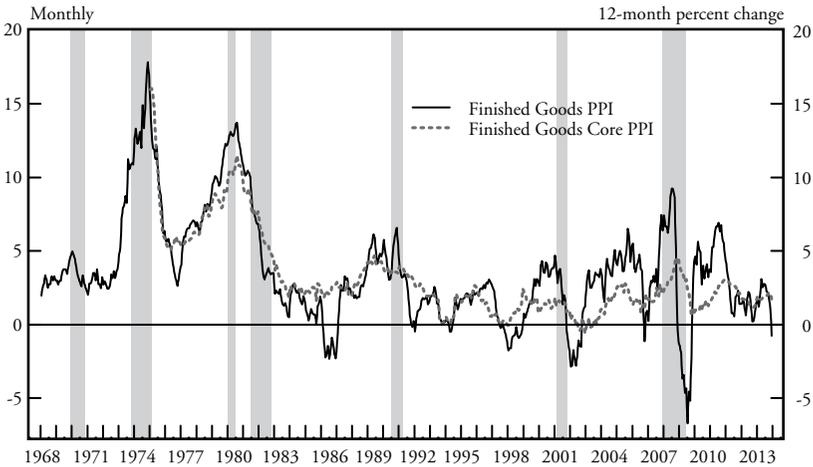
Notes: All series are seasonally adjusted. The shaded vertical bars denote NBER-dated recessions.

unemployment (Orphanides and Williams 2013) and by the OPEC-induced increases in oil prices (Hamilton 1983, 2003). In contrast, the gradual step down in PPI inflation during the early 1980s was due to the tightening of monetary policy under then-Chairman Volcker, who was determined to fight inflation and reverse the rise in inflation expectations (Lindsey, Orphanides and Rasche 2005). Since the mid-1980s, PPI inflation—both overall and core—has stabilized at about 2 percent, a pattern consistent with the well-anchored inflation expectations engendered by credible monetary policy, aimed at achieving its so-called dual mandate.[6]

In Table 1, we zero in on the cyclical dynamics of producer prices. First, we divide the 1969-2014 period into three subperiods, corresponding roughly to the three different inflation regimes discussed above. For each NBER-dated recession in our sample, we report the average annualized rate of change in both the overall and core producer prices—PPI and PPIxFE, respectively—calculated from peak to trough of the downturn. To compare the behavior of producer prices between economic contractions and expansions, we also report the average annualized change in both price indexes calculated over the period in which the economy was in an expansion during the specified subperiod. The column labeled GSCI contains the corresponding

Table 1
Cyclical Behavior of Producer Prices, 1969-2014

	Average Annualized Change (percent)			
	PPI	PPIxFE[a]	GSCI[b]	IP
Sample period: Jan. 1969-Dec. 1979				
Recession: Dec. 1969-Nov. 1970 (11)	2.50	.	14.36	–6.56
Recession: Nov. 1973-Mar. 1975 (16)	13.62	14.70	17.57	–10.42
Excluding recessions (100)	6.82	6.90	20.64	5.69
Sample period: Jan. 1980-Dec. 1984				
Recession: Jan. 1980-Jul. 1980 (6)	12.32	10.29	7.35	–13.63
Recession: Jul. 1981-Nov. 1982 (16)	3.56	5.20	–1.08	–6.73
Excluding recessions (34)	3.33	3.78	–0.56	7.24
Sample period: Jan. 1985-Dec. 2014				
Recession: Jul. 1990-Mar. 1991 (8)	4.26	4.09	24.31	–5.75
Recession: Mar. 2001-Nov. 2001 (8)	–2.90	0.70	–39.41	–5.64
Recession: Dec. 2007-Jun. 2009 (18)	0.70	3.34	–37.45	–12.46
Excluding recessions (320)	2.40	1.85	7.46	3.38

Notes: PPI = finished goods producer price index; PPIxFE = finished goods producer price index, excluding food and energy; GSCI = S&P Goldman Sachs commodity price index; and IP = industrial production. The number of monthly observations in each sample period is reported in parentheses. PPI, PPIxFE, and IP are seasonally adjusted.
[a] Data start in January 1974
[b] Data start in January 1970

average annualized changes in the Standard & Poor's Goldman Sachs commodity price index—a proxy for cost-push shocks—while the column labeled IP shows the behavior of industrial production, a gauge of the severity of a downturn.[7]

The surge in commodity prices during the 1973-75 recession is clearly evident in the behavior of producer prices, which increased sharply during the downturn. While commodity prices rose at a fairly brisk pace during the 1980 recession, both the overall and core PPI increased at significantly faster rates, reflecting, in large part, the unanchoring of inflation expectations that occurred during the previous decade. In contrast, the 1981-82 slump saw little change in commodity prices, on average. And although industrial production fell substantially during the downturn, producer prices increased at a faster average rate than during the expansionary phase of the mid-1980s subperiod.

The resilience of producer prices in response to the emergence of substantial economic slack is also evident during the three most recent recessions. The sharp increase in commodity prices prompted by the First Gulf War confounds the behavior of PPI inflation during the 1990-91 recession to some extent. Nonetheless, both the overall and core indexes rose at an average annual rate of about 4 percent during this period, while industrial output contracted sharply. During the bursting of the tech bubble in 2001, overall producer prices fell, on average, but the decline is due almost solely to the plunge in prices in the immediate aftermath of the September 11 terrorist attacks—in October 2001, the Bureau of Labor Statistics (BLS) reported the PPI dropped almost 20 percent at an annual rate. As noted earlier, the Great Recession offers perhaps the most puzzling behavior of producer prices from a recent historical perspective. With commodity prices in a free fall, the overall PPI was about flat, on average. However, core producer prices increased at an annual average rate of more than 3 percent during the 18 months of the downturn, in spite of a massive drop in industrial production.

An especially striking way to illustrate how economic slack has failed to materialize in disinflationary pressures over the past three decades or so is shown in Chart 2. Panel A depicts the behavior of detrended core producer prices two years before and two years after each NBER-dated cyclical peak since the early 1980s. Panel B, by contrast, shows the corresponding dynamics of detrended industrial output, our measure of economic slack. In each case, we estimate the deterministic linear trend over the 24 months prior to the specified cyclical peak and then extrapolate it forward over the subsequent 24 months. As shown in Panel A, with the exception of the 2001 recession, core prices showed virtually no deceleration during the past five economic downturns, relative to their pre-recession trends. In contrast, as shown in Panel B, industrial output declined markedly—relative to its pre-recession trend—during these episodes.

The lack of sensitivity of producer prices to cyclical changes in resource utilization—a key determinant of inflation dynamics in New Keynesian models—is also a pervasive phenomenon in the cross section. The solid line in Chart 3 shows the net proportion of (six-digit

Chart 2
Cyclical Behavior of Core Producer Prices
and Industrial Production

A. Core Producer Prices

B. Industrial Production

Index (peak=100)   Index (peak=100)   Index (peak=100)   Index (peak=100)

Months to and from Business Cycle Peaks

Months to and from Business Cycle Peaks

▬▬ Peak: Jan. 1980   ▬▬ Peak: Jul. 1981   ▬▬ Peak: Jul. 1990   ┄┄ Peak: Mar. 2001   ▬ ▬ Peak: Dec. 2007

Notes: The lines in Panel A depict the behavior of core producer prices (PPIxFE) 24 months before and 24 months after the specified NBER-dated cyclical peak, while the lines in Panel B depict the corresponding cyclical behavior of (manufacturing) industrial production. All series are plotted as deviations from their respective linear deterministic trends, estimated over the 24 months preceding the specified NBER-dated cyclical peak.

NAICS) industries that increased prices in any given quarter, while the dotted line shows the net proportion of (five-digit and six-digit NAICS) industries that increased production over the same period.[8] These two series measure the difference between the share of industries that increased prices/production and the share of industries that decreased prices/production in any given quarter and thus provide an indicator of adjustment at the extensive margin for these two dimensions of firms' behavior. As indicated by the solid line, it is extraordinarily rare to observe firms lowering their prices, on balance. Even at the nadir of the recent financial crisis in the latter part of 2008, only about one-fifth of narrowly defined industries, on net, decreased prices. In contrast, almost 80 percent of industries cut quarterly production, on net, during this period. In fact, during the early phase of the Great Recession, the net percent of industries that increased prices rose substantially, despite a significant retrenchment in industrial activity.

Chart 3
Net Percent of Industries Changing Prices
and Production, 1973-2014

Notes: The solid line shows the net percent of industries (six-digit NAICS) that increased prices during the specified quarter, while the dotted line shows the net percent of industries (five- and six-digit NAICS) that increased production. The net percent is defined as the number of industries that increased prices/production less the number of industries that decreased prices/production, expressed as a percent of the total number of industries in a given quarter. All underlying industry-level series are seasonally adjusted. The shaded vertical bars denote the NBER-dated recessions.

III.   Producer Prices and Financial Factors

In this section, we use micro-level data to analyze how financial factors affect firms' pricing behavior. We consider two levels of data disaggregation in the empirical analysis. In the first part, we utilize the detailed (six-digit NAICS) industry-level PPIs published by the BLS, which we merge with the corresponding industry-level data on industrial production published by the Federal Reserve. In addition to the considerable variation in producer prices across such narrowly defined industries, another advantage of these data is that they are available since the early 1970s and, therefore, cover a number of business cycles. In the second part, we exploit the combination of the item-level and firm-level heterogeneity in the matched PPI—Compustat data set constructed by GSSZ and provide new complimentary evidence on how firms' financial conditions affected their pricing behavior during the 2008 financial crisis.[9]

III.i   Evidence from Industry-Level Data

Our goal in this section is to study the relationship between industry-level inflation dynamics and aggregate financial conditions.

Specifically, we are interested in the extent to which the response of industry-level producer prices to aggregate financial conditions varies across industries, according to the likelihood that firms in a given industry face financial constraints and, hence, may be particularly sensitive to changes in financial conditions. Our unit of observation is PPI inflation at the six-digit NAICS level, which we are able to match to industry-level production data.[10] However, as we discuss below, we are able to construct effective measures of the extent to which firms within a given industry face financial frictions only at the four-digit level.

To examine formally the relationship between the behavior of industry-level producer prices and changes in aggregate financial conditions, we therefore estimate the following regression:

$$\Delta_h \log \text{PPI}_{i,t+h} = \alpha_i + \sum_{s=0}^{h-1} \beta_s \Delta_1 \log \text{PPI}_{i,t-s} + \sum_{s=0}^{h-1} \gamma_s \Delta_1 \log \text{IP}_{i,t-s}$$

$$+ \sum_{k=1}^{K} \theta_k \text{NAICS4}[i] \text{xEBP}_t + \sum_{k=1}^{K} \lambda_k \text{NAICS4}[i] \text{x} \Delta_h \log \text{GSCI}_t + \in_{i,t+h,}$$

where t indexes time (in months); $\Delta_h X_t \equiv \dfrac{1200}{h}(X_t - X_{t-h})$ for a generic variable X; and NAICS4$[i]$ is a function that maps a six-digit NAICS industry code $i = 1, ..., N$ into its corresponding four-digit NAICS industry code $k = 1, ..., K$ $(K<N)$. This specification relates the industry i's annualized PPI inflation between months t and $t + h$ to its own current and past inflation, current and past changes in production in the same industry ($\Delta_1 \log \text{IP}_{i,t-s}$), the *excess bond premium* (EBP$_t$) in month t—the current state of financial conditions (see Gilchrist and Zakrajšek 2012)—and the commodity price inflation from t-h to t ($\Delta_h \log \text{GSCI}_t$). Note that we allow the coefficients on the two macro factors—financial conditions and commodity price inflation—to differ across industries at the four-digit NAICS level. This flexible empirical framework allows us to examine the extent to which heterogeneity in the EBP factor loadings is related to the likelihood of binding financing constraints across different industries.

The use of the excess bond premium as an indicator of the state of financial conditions is motivated by the extraordinary events of the 2007-09 financial crisis, which has led to the development of

theoretical models that emphasize the implications of balance sheet conditions of financial intermediaries for asset prices and real economic outcomes (see He and Krishnamurthy 2012, 2013; Adrian and Boyarchenko 2013; Brunnermeier and Sannikov 2014). Empirical support for these theories is provided by Gilchrist and Zakrajšek (2012), who decompose corporate bond credit spreads into two components: (1) a component capturing the usual countercyclical movements in expected defaults; and (2) a component capturing deviations in the pricing of corporate debt claims relative to the expected default risk of the issuer—that is, the EBP. It turns out that the vast majority of the well-documented information content of credit spreads for future economic activity is attributable to movements in the EBP and that fluctuations in the EBP are closely related to changes in the financial condition of broker-dealers, highly leveraged financial intermediaries that play a key role in financial markets.[11] This evidence strongly supports the view that deviations in the pricing of long-term corporate bonds relative to the expected default risk of the underlying issuer captures shifts in the effective risk aversion of the financial sector; in turn, increases in risk aversion lead to a tightening of financial conditions and a contraction in the supply of credit (see López-Salido, Stein and Zakrajšek 2015).

Chart 4 shows this indicator of the tightness of financial conditions from January 1973 to December 2012. Clearly evident is the countercyclical nature of changes in financial conditions, with the EBP generally rising in advance of, and during, economic downturns. To provide a set of benchmark estimates, Panel A of Table 2 reports how these changes in financial conditions affect producer prices at different horizons, assuming a common coefficient on the EBP for all four-digit NAICS industry groups.[12] According to the entries in the table, the coefficient on the EBP is negative and statistically highly significant at the forecast horizons ranging from three to 12 months.[13] In economic terms, these estimate simply that an increase in EBP of a full percentage point—a tightening of financial conditions of roughly two standard deviations—is estimated to shave off almost 1.25 percentage points from (annualized) PPI inflation over the near term and medium term. The negative sign on the EBP coefficients is consistent with the standard "financial accelerator" view

Chart 4
Excess Bond Premium, 1973-2012
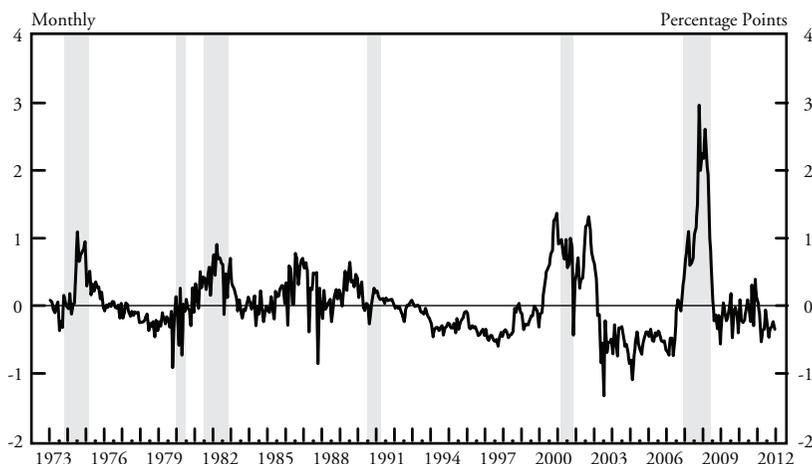
Notes: The solid line shows an estimate of the monthly excess bond premium, an indicator of the tightness of financial conditions; see Gilchrist and Zakrajšek (2012) for details. The shaded vertical bars denote NBER-dated recessions.

that a tightening of financial conditions, by inducing a slowdown in economic activity, will also lead to a deceleration in producer prices.

Not surprisingly, the entries in the table also indicate a significant role for commodity prices in shaping the future trajectory of producer prices—the null hypothesis that the industry-specific coefficients on commodity price inflation are jointly equal to zero is overwhelmingly rejected by the data. At the same time, while industry-level PPI inflation dynamics exhibit a modest degree of persistence, the corresponding movements in production appear to be completely uninformative about the behavior of future producer prices: At all forecast horizons, we do not reject the exclusion of the coefficients on current and lagged growth of industrial production; at the 12-month forecast horizon, however, the corresponding sum of coefficients is positive and statistically significant, but the implied effect on year-ahead PPI inflation is negligible in economic terms. This striking lack of sensitivity of future movements in producer prices to changes in current and past production is consistent with the results in Tables 1 and 2, which highlight the resilience of producer prices in response to the emergence of significant and, in many instances, long-lasting economic slack.

Table 2
Producer Prices and Financial Conditions, 1973-2013

A. Industry-Invariant Coefficients on the EBP

	Forecast Horizon (months)		
	$h = 3$	$h = 6$	$h = 12$
EBP_t	−1.114***	−1.161**	−1.294***
	(0.384)	(0.539)	(0.400)
Exclusion tests (*p*-values)			
NAICS4 × $\Delta_h \log \text{GSCI}_t$	<.001	<.001	<.001
$\Delta_1 \log \text{PPI}_{i,t-s}$ (s = 0, . . . , h − 1)	<.001	<.001	<.001
$\Delta_1 \log \text{IP}_{i,t-s}$ (s = 0, . . . , h − 1)	0.668	0.218	0.223
Sum of coefficients on			
$\Delta_1 \log \text{PPI}_{i,t-s}$ (s = 0, . . . , h − 1)	0.194***	0.143***	−0.084*
	(0.024)	(0.040)	(0.048)
$\Delta_1 \log \text{IP}_{i,t-s}$ (s = 0, . . . , h − 1)	0.001	0.008	0.035***
	(0.006)	(0.008)	(0.012)
R^2 (within)	0.086	0.075	0.055

B. Industry-Specific Coefficients on the EBP

	Forecast Horizon (months)		
	$h = 3$	$h = 6$	$h = 12$
Exclusion tests (*p*-values)			
NAICS4 × EBP_t	<.001	<.001	<.001
NAICS4 × $\Delta_h \log \text{GSCI}_t$	<.001	<.001	<.001
$\Delta_1 \log \text{PPI}_{i,t-s}$ (s = 0, . . . , h − 1)	<.001	<.001	<.001
$\Delta_1 \log \text{IP}_{i,t-s}$ (s = 0, . . . , h − 1)	0.712	0.235	0.305
Sum of coefficients on			
$\Delta_1 \log \text{PPI}_{i,t-s}$ (s = 0, . . . , h − 1)	0.186***	0.135***	−0.087**
	(0.025)	(0.042)	(0.045)
$\Delta_1 \log \text{IP}_{i,t-s}$ (s = 0, . . . , h − 1)	−0.000	0.007	0.034***
	(0.006)	(0.009)	(0.012)
R^2 (within)	0.092	0.085	0.074

Notes: Sample period: Monthly data from January 1973 to December 2013 ($\bar{T}_i = 267.6$); No. of six-digit NAICS industries = 237; Obs. = 63,413. In each specification, the dependent variable is $\Delta_h \log \text{PPI}_{i,t+h}$, the annualized log-difference of PPI in (six-digit NAICS) industry i from t to $t + h$. Explanatory variables: EBP_t = excess bond premium at t; $\Delta_h \log \text{GSCI}_t$ = annualized log-difference of the GSCI from $t–h$ to t; $\Delta_1 \log \text{PPI}_{i,t-s}$ = annualized log-difference of PPI in industry i from $t–s – 1$ to $t–s$ (s= 0, . . . , h–1); and $\Delta_1 \log \text{IP}_{i,t-s}$ = annualized log-difference of IP in industry i from $t–s – 1$ to $t–s$ (s = 0, . . . , $h–1$). Specifications in Panel A impose a common coefficient on the EBP_t, while the coefficients on $\Delta_h \log \text{GSCI}_t$ are allowed to differ across four-digit NAICS industries; specifications in Panel B also allow the coefficients on the EBP_t to differ across four-digit NAICS industries. All specifications include industry (six-digit NAICS) fixed effects and are estimated by OLS. Heteroscedasticity- and autocorrelation-consistent asymptotic standard errors reported in parentheses are computed according to Driscoll and Kraay (1998) with the lag length equal to h: * $p < .10$; ** $p < .05$; and *** $p < .01$.

As noted above, the cross-sectional aspect of our data allows us to relax the assumption of homogeneity of responses in industry-specific inflation dynamics to changes in financial conditions. Panel B of Table 2 summarizes the estimation results from this exercise. The comparison of the (within) R^2s across the two panels reveals an improvement in the in-sample fit as a result of letting the coefficients on the EBP vary across the four-digit NAICS industry groups. As indicated by the *p*-values of the exclusion tests, we clearly reject the null hypothesis that the coefficients on the EBP are jointly equal to zero. All other results, however, are very similar to those reported in Panel A.

Our interest, however, lies not in the individual EBP coefficients per se. Rather, we are interested in whether variation in these factor loadings is systematically related to industry characteristics, especially the degree to which firms in any given industry may be subject to financing constraints. Of course, the presence of binding financial constraints—the existence of a systematic countercyclical wedge between the cost of external and internal funds—is not directly observable, either at the firm or industry level. As a result, we rely on the Hadlock and Pierce (2010) sizeage (SA) index to measure the likelihood of financing constraints at the industry level.

Expanding on the text-based approach pioneered by the influential work of Kaplan and Zingales (1997), Hadlock and Pierce (2010) examine the 10-K filings of a random sample of 356 firms over 1995-2004, looking for direct evidence of firms identifying themselves as financially constrained.[14] Based on this classification, they use ordered logit analysis to construct an index of financing constraints that loads negatively on firm size, positively on size squared, and negatively on firm age.[15] Compared with other commonly used proxies, the main advantage of the SA-index is that it relies solely on firm size and age—two relatively exogenous firm characteristics—to identify firms that are facing a high likelihood of financing constraints.[16] Using their methodology, we construct the SA-index for all U.S. nonfinancial firms that appear in Compustat since 1973. We then compute the median SA-index across all firm/year observations in each four-digit NAICS industry group. Chart 5 shows the scatter plot of the industry-specific EBP coefficients from the

Chart 5
Sensitivity of Industry-Level Producer Prices
to Financial Conditions, 1973-2013
(By Industry-Specific Indicator of Financial Constraints)
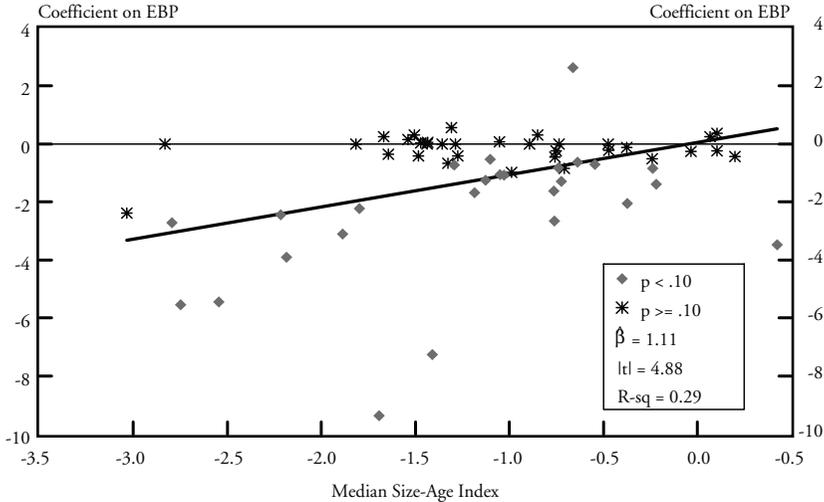
Notes: No. of (four-digit NAICS) industries = 59. The chart shows the relationship between the median SA-index of financing constraints at the four-digit NAICS level during the 1973-2013 period and the corresponding industry-specific estimates of the coefficient on the EBP; the dependent variable is $\Delta_{12} \log PPI_{i,t+12}$, the log-difference of PPI in (six-digit NAICS) industry i from t to $t+12$ (see the text and notes to Table 2 for details). Observations plotted as diamonds (♦) indicate coefficients that are different from zero at the 10-percent, or lower, significance level; observations plotted as stars (✳) are statistically not different from zero at the 10-percent level. Smaller values of the size-age index indicate a smaller likelihood of financial constraints.

12-month horizon specification in Panel B of Table 2 against this indicator of financial constraints. First, note that the estimated EBP coefficients are generally negative—the average of the coefficients across the 59 (four-digit NAICS) industries is -1.143, a value very close to the estimate of the common EBP coefficient reported in Panel A of the table. However, what is interesting is the strong negative relationship between the estimated EBP factor loadings and the SA-index.[17] This negative relationship implies that industries in which prices are more sensitive—in absolute terms—to changes in financial conditions are also industries in which a typical firm is less likely to be financially constrained. Put differently, industries in which firms are more likely to face financing constraints exhibit a significantly more muted response of inflation at the 12-month forecast horizon to changes in financial conditions. It is also worth noting that this pattern holds robustly across the different horizons reported in Table 2.

Chart 6
Sensitivity of Industry-Level Producer Prices
to Commodity Prices, 1973-2013
(By Industry-Specific Indicator of Financial Constraints)
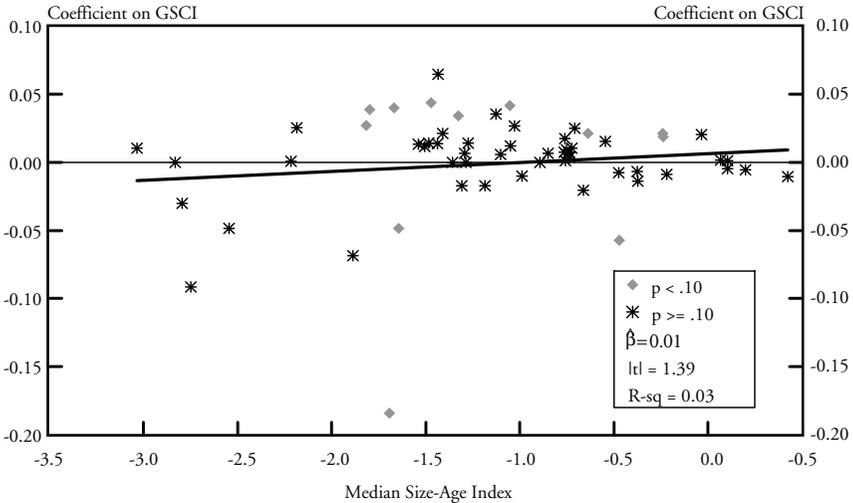
Notes: No. of (Four-digit NAICS) industries = 59. The chart shows the relationship between the median SA-index of financing constraints at the Four-digit NAICS level during the 1973-2013 period and the corresponding industry-specific estimates of the coefficient on Δ_{12} log $GSCI_t$, the log-difference in the GSCI from t–11 to t; the dependent variable is Δ_{12} log $PPI_{i,t+12}$, the log-difference of PPI in (six-digit NAICS) industry i from t to $t + 12$ (see the text and notes to Table 2 for details). Observations plotted as diamonds (♦) indicate coefficients that are different from zero at the 10-percent, or lower, significance level; observations plotted as stars (✱) are statistically not different from zero at the 10-percent level. Smaller values of the size-age index indicate a smaller likelihood of financial constraints.

In contrast, as shown in Chart 6, there is no systematic relationship between the industry-specific coefficients on commodity price inflation and the SA-index at the 12-month horizon. This result argues against the view that differences in the sensitivity of prices to changes in financial conditions across industries reflect differences in the associated cross-sectional sensitivity of producer prices to fluctuations in commodity prices.

III.ia   Subsample Stability

The results reported in Table 2 are based on the behavior of producer prices from 1973 to 2013, a period encompassing several distinct inflation regimes. This period also saw significant changes in the conduct of monetary policy, which—in addition to breaking the inflationary spiral of the 1970s—have ultimately led to the stabilization of inflation expectations, a crucial determinant of the firms'

pricing behavior. To ensure that our results are robust to this change in inflation expectations, this section repeats the above analysis for the post-1985 period.[18]

As shown in Table 3, the effect of changes in financial conditions on the subsequent behavior of producer prices during 1985-2013 is very similar to that estimated over the full sample period. Imposing a restriction of a common coefficient on the EBP (Panel A) yields estimates that are, in economic terms, indistinguishable from those reported in Panel A of Table 2—as before, a 1 percentage point jump in the EBP is estimated to reduce PPI inflation over the subsequent year by about 1.25 percentage points. The persistence of inflation dynamics—as measured by the sum of coefficients on current and lagged one-month PPI inflation—is also very similar across the two subperiods.

Allowing the coefficients on EBP to vary across the four-digit NAICS industries (Panel B) also yields very similar results. Though not reported, the correlation between industry-specific EBP coefficients across the two sample periods is 0.97, indicating little change of the sensitivity of industry-level producer prices to changes in economywide financial conditions. This result is confirmed by Chart 7, which shows the scatter plot of the industry-specific EBP coefficients from the 12-month horizon regression specification against the corresponding median SA-index.[19] The general pattern of coefficients is virtually identical to that in Chart 5 and again indicates that industries in which firms face a higher likelihood of financial constraints exhibit a significantly more attenuated response of prices to changes in financial conditions.[20]

The last robustness check of our results concerns the influence of the Great Recession, clearly an extreme economic event by recent historical standards. Table 4 summarizes results from our standard industry-level pricing regressions estimated over 1973-2007. According to the entries in Panel A, ending the sample in December 2007 has no appreciable effect on the average estimate of the impact of changes in aggregate financial conditions on inflation dynamics. Consistent with our full sample results, an increase of 1 percentage point in the EBP is estimated to shave off about 1.5 percentage points from PPI inflation over the subsequent year.

Table 3
Producer Prices and Financial Conditions, 1985-2013

A. Industry-Invariant Coefficients on the EBP

	Forecast Horizon (months)		
	$h = 3$	$h = 6$	$h = 12$
EBP_t	−1.135***	−1.115**	−1.223***
	(0.419)	(0.554)	(0.380)
Exclusion tests (*p*-values)			
NAICS4 × Δ_h logGSCI$_t$	<.001	<.001	<.001
Δ_1 log PPI$_{i,t-s}$ (s =0, . . . , h−1)	<.001	<.001	<.001
Δ_1 log IP$_{i,t-s}$ (s =0, . . . , h−1)	0.202	0.139	0.185
Sum of coefficients on			
Δ_1 log PPI$_{i,t-s}$ (s =0, . . . , h−1)	0.162***	0.095**	−0.129**
	(0.028)	(0.046)	(0.062)
Δ_1 log IPi,t−s (s = 0, . . . , h − 1)	−0.009*	0.001	0.038***
	(0.005)	(0.008)	(0.012)
R^2 (within)	0.087	0.068	0.065

B. Industry-Specific Coefficients on the EBP

	Forecast Horizon (months)		
	$h = 3$	$h = 6$	$h = 12$
Exclusion tests (*p*-values)			
NAICS4 × EBP_t	<.001	<.001	<.001
NAICS4 × Δ_h logGSCI$_t$	<.001	<.001	<.001
Δ_1 log PPI$_{i,t-s}$ (s =0, . . . , h−1)	<.001	<.001	<.001
Δ_1 log IP$_{i,t-s}$ (s =0, . . . , h−1)	0.189	0.137	0.190
Sum of coefficients on			
Δ_1 log PPI$_{i,t-s}$ (s =0, . . . , h−1)	0.152***	0.084**	−0.133**
	(0.029)	(0.048)	(0.059)
Δ_1 log IP$_{i,t-s}$ (s =0, . . . , h−1)	−0.011**	−0.002	0.037***
	(0.006)	(0.008)	(0.012)
R^2 (within)	0.094	0.082	0.090

Note: Sample period: Monthly data from January 1985 to December 2013 ($\overline{T}$ i = 230.2); No. of six-digit NAICS industries = 237; Obs. = 54,557. In each specification, the dependent variable is Δ_h log PPI$_{i,t+h}$,the annualized log-difference of PPI in (six-digit NAICS) industry *i* from *t* to *t + h*. Explanatory variables: EBP$_t$ = excess bond premium at *t*; Δ_h log GSCI$_t$ = annualized log-difference of the GSCI from *t − h* to *t*; Δ_1 log PPI$_{i,t-s}$ = annualized log-difference of PPI in industry *i* from *t−s − 1* to *t − s* (s=0, . . . , h−1); and Δ_1 log IP*j,t−s* = annualized log-difference of IP in industry *i* from *t−s − 1* to *t−s* (s = 0, . . . , h− 1). Specifications in Panel A impose a common coefficient on the EBP$_t$, while the coefficients on Δ_h log GSCI*t* are allowed to differ across four-digit NAICS industries; specifications in Panel B also allow the coefficients on the EBP*t* to differ across four-digit NAICS industries. All specifications include industry (six-digit NAICS) fixed effects and are estimated by OLS. Heteroscedasticity- and autocorrelation-consistent asymptotic standard errors reported in parentheses are computed according to Driscoll and Kraay (1998) with the lag length equal to *h*: * *p* < .10; ** *p* < .05; and *** *p* < .01.

Chart 7
Sensitivity of Industry-Level Producer Prices
to Financial Conditions, 1985-2013
(By Industry-Specific Indicator of Financial Constraints)
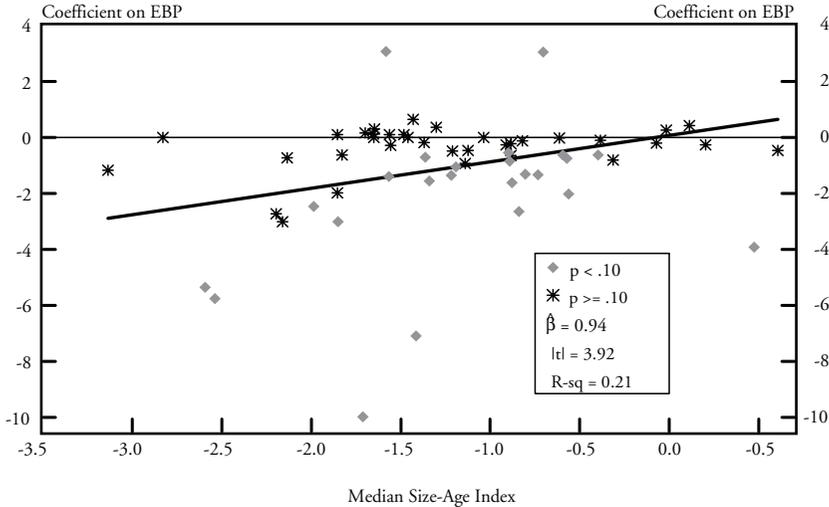
Median Size-Age Index

Notes: No. of (four-digit NAICS) industries = 59. The chart shows the relationship between the median SA-index of financing constraints at the 4-digit NAICS level during the 1985-2013 period and the corresponding industry-specific estimates of the coefficient on the EBP; the dependent variable is 12 log PPI$_{i,t+12}$, the log-difference of PPI in (Six-digit NAICS) industry i from t to t+12 (see the text and notes to Table 3 for details). Observations plotted as diamonds ( ) indicate coefficients that are different from zero at the 10-percent, or lower, significance level; observations plotted as stars (✱) are statistically not different from zero at the 10-percent level. Smaller values of the size-age index indicate a smaller likelihood of financial constraints.

Chart 8 shows the familiar scatter plot of the industry-specific EBP coefficients from the 12 month horizon regression specification against the corresponding median SA-index.[21] Although in statistical terms, the relationship between the industry-specific EBP loadings and the SA-index is somewhat less precise compared with those based on samples that include the Great Recession, the general pattern remains the same: Industries in which firms face a higher likelihood of financial constraints exhibit a notably more attenuated response of prices to changes in aggregate financial conditions.[22]

All told, the results above point to a significant role of financial factors in determining the cyclical dynamics of producer prices. In general, a tightening of financial conditions is associated with a marked deceleration of producer prices over short-term and medium-term horizons, a pattern consistent the concomitant weakening of the economic outlook. However, the response of producer prices to changes

Table 4
Producer Prices and Financial Conditions, 1973-2007

A. Industry-Invariant Coefficients on the EBP

	Forecast Horizon (months)		
	$h = 3$	$h = 6$	$h = 12$
EBP_t	−1.207***	−1.274***	−1.400**
	(0.342)	(0.369)	(0.606)
Exclusion tests (p-values)			
NAICS4 × $\Delta_h \log GSCI_t$	<.001	<.001	<.001
$\Delta_I \log PPI_{i,t-s}$ (s = 0, . . . , h−1)	<.001	<.001	<.001
$\Delta_I \log IP_{i,t-s}$ (s=0, . . . , h−1)	0.035	0.082	0.228
Sum of coefficients on			
$\Delta_I \log PPI_{i,t-s}$ (s =0, . . . , h−1)	0.185***	0.205***	−0.062*
	(0.027)	(0.030)	(0.036)
$\Delta_I \log IP_{i,t-s}$ (s=0, . . . , h−1)	0.013***	0.026***	0.030**
	(0.005)	(0.009)	(0.013)
R^2 (within)	0.057	0.066	0.058

B. Industry-Specific Coefficients on the EBP

	Forecast Horizon (months)		
	h = 3	h = 6	h = 12
Exclusion tests (p-values)			
NAICS4 × EBP_t	<.001	<.001	<.001
NAICS4 × $\Delta_h \log GSCI_t$	<.001	<.001	<.001
$\Delta_I \log PPI_{i,t-s}$ (s=0, . . . , h−1)	<.001	<.001	<.001
$\Delta_I \log IP_{i,t-s}$ (s= 0, . . . , h−1)	0.033	0.079	0.395
Sum of coefficients on			
$\Delta_I \log PPI_{i,t-s}$ (s = 0, . . . , h −1)	0.181***	0.201***	−0.068*
	(0.027)	(0.031)	(0.037)
$\Delta_I \log IP_{i,t-s}$ (s = 0, . . . , h−1)	0.013***	0.026***	0.029**
	(0.005)	(0.009)	(0.013)
R^2 (within)	0.060	0.072	0.072

Notes: Sample period: Monthly data from January 1973 to December 2007 ($\overline{T}$ = 253.3); No. of six-digit NAICS industries = 201; Obs. = 50,903. In each specification, the dependent variable is $\Delta_h \log PPI_{i,t+h}$, the annualized log-difference of PPI in (six-digit NAICS) industry i from t to t + h. Explanatory variables: EBP_t = excess bond premium at t; h log $GSCI_t$ = annualized log-difference of the GSCI from t − h to t; 1 log $PPI_{i,t-s}$ = annualized log-difference of PPI in industry i from t − s − 1 to t − s (s = 0, . . . , h − 1); and 1 log $IP_{j,t-s}$ = annualized log-difference of IP in industry i from t − s − 1 to t − s (s = 0, . . . , h − 1). Specifications in Panel A impose a common coefficient on the EBP_t, while the coefficients on h log $GSCI_t$ are allowed to differ across four-digit NAICS industries; specifications in Panel B also allow the coefficients on the EBP_t to differ across four-digit NAICS industries. All specifications include industry (six-digit NAICS) fixed effects and are estimated by OLS. Heteroscedasticity- and autocorrelation-consistent asymptotic standard errors reported in parentheses are computed according to Driscoll and Kraay (1998) with the lag length equal to h: * p < .10; ** p < .05; and *** p < .01.

Chart 8
Sensitivity of Industry-Level Producer Prices
to Financial Conditions, 1973-2007
(By Industry-Specific Indicator of Financial Constraints)

Notes: No. of (four-digit NAICS) industries = 59. The chart shows the relationship between the median SA-index of financing constraints at the four-digit NAICS level during the 1985-2013 period and the corresponding industry-specific estimates of the coefficient on the EBP; the dependent variable is 12 log PPI$_{i,t+12}$, the log-difference of PPI in (six-digit NAICS) industry *i* from t to *t+12* (see the text and notes to Table 3 for details). Observations plotted as diamonds (◆) indicate coefficients that are different from zero at the 10-percent, or lower, significance level; observations plotted as stars (✳) are statistically not different from zero at the 10-percent level. Smaller values of the size-age index indicate a smaller likelihood of financial constraints.

in aggregate financial conditions differs significantly across industries. In particular, prices in industries in which firms are likely to face financial constraints systematically exhibit a notably more attenuated response to the tightening of financial conditions, compared with industries where firms are less likely to be financially constrained. This cross-sectional pattern is not related to the degree of sensitivity with which prices in different industries react to movements in commodity prices and holds robustly across the last 40 years of data.

III.ii   Evidence from Firm-Level Data

In this section, we provide additional evidence on the role of financial factors as an important determinant of firms' pricing behavior. Specifically, we exploit the granularity of the matched PPI-Compustat sample constructed by GSSZ to examine how differences in the condition of firms' balance sheets in 2006 influenced their pricing behavior during the height of the crisis in 2008.

There is widespread agreement among economists that the 2007-09 financial crisis saw a significant breakdown in the financial intermediation process, in both the arm's-length capital markets and in the form of credit intermediated through the banking sector. Banks, in particular, tightened lending standards and terms and in the process slashed their customers' existing lines of credit to reduce their off-balance-sheet credit exposures in response to the acute pressures on their capital and liquidity positions (Bassett, Gilchrist, Weinbach and Zakrajšek 2014; Bassett, Chosak, Driscoll and Zakrajšek 2014). At the same time, many banks also experienced a "run" on their outstanding credit facilities, a dynamic that significantly reinforced the retrenchment in business lending (Ivashina and Scharfstein 2010).[23] This pullback in the supply of contingent liquidity that businesses rely upon heavily exerted a significant strain on corporate balance sheets, forcing companies to turn to internal sources of liquidity to cover their immediate debt obligations and fund operations (Campello, Giambona, Graham and Harvey 2011).[24]

Given these developments, GSSZ argue that the ratio of cash and short-term investment (i.e., liquid assets) to total assets provides an especially good proxy for the strength of firms' balance sheets during the crisis.[25] Accordingly, GSSZ estimate the item-level response of inflation over a given quarter to the firm's liquidity position determined over the prior year. They also take advantage of the discrete nature of price-adjustment at the micro level and estimate the effect of a firm's liquidity position on the likelihood that a firm raises, keeps unchanged, or lowers its nominal prices. GSSZ use a time-varying coefficient estimates to document that the probability that a firm raises prices, as well as the three-month-ahead inflation, becomes highly sensitive to a firm's liquidity position as the financial crisis unfolds.

GSSZ's estimates do not specifically seek to control for possible endogeneity in the firms' liquidity positions as the crisis unfolds, however. To address this concern, we focus on the firms' pre-crisis liquidity positions—that is, the amount of liquid assets on the firms' balance sheet in 2006, arguably prior to any widespread concerns that the U.S. economy was heading toward a financial crisis. Specifically, we examine how ex-ante differences in the firms' liquidity positions affected the entire distribution of price changes in 2008. To do

so, we follow the methodology of GSSZ and calculate the *industry-adjusted* price changes from December 2007 to December 2008 for all firms in their data set.[26] We then use the standard quantile regression methodology (see Koenker and Bassett 1978) to estimate the effect of the 2006 liquidity ratio on these firm-level (12-month) price changes at various quantiles of their distribution.

The solid line in Chart 9 shows how the estimated marginal effect of the firms' 2006 liquidity ratio on the 12-month price change in 2008 varies across the distribution of prices changes; for comparison the dotted line shows the OLS estimate of the corresponding marginal effect. Clearly, this relationship is not constant across the distribution of price changes during this period. In fact, it is evident only at the upper half of the distribution, indicating differences in the firms' 2006 liquidity positions primarily affected their ability to raise prices in 2008. For example, moving from the 10th to the 90th percentile of the cross-sectional distribution of liquidity ratio in 2006, our estimate simply that a "low" liquidity firm would see its prices decline—relative to its industry trend—about one-third of a percentage point during 2008, compared with a drop of nearly 6.5 percentage points for its "high" liquidity counterpart, when the effect of corporate liquidity is evaluated at the median of the price change distribution. At the 90th percentile of the distribution—admittedly a fairly extreme event—this differential impact increases to more than 18 percentage points.

These results confirm the original findings of GSSZ, who show that as the 2007-09 financial crisis unfolded, pricing behavior at the level of an individual firm became highly sensitive to a firm's financial position. Consistent with their results is the fact that low levels of liquidity in 2006 had no effect on the firm-level inflation rates at the bottom half of the price-change distribution in 2008, but had a significant effect—both economically and statistically—on firms that increased their prices relative to their industry average during this period.

All told, our empirical results imply that changes in financial conditions significantly shape dynamics of producer prices during the course of a business cycle. Our industry-level analysis delivers a robust finding that prices in industries that rely more heavily on

Chart 9
Corporate Liquidity and Firms' Pricing Behavior in 2008
(Quantile Regression Estimates)
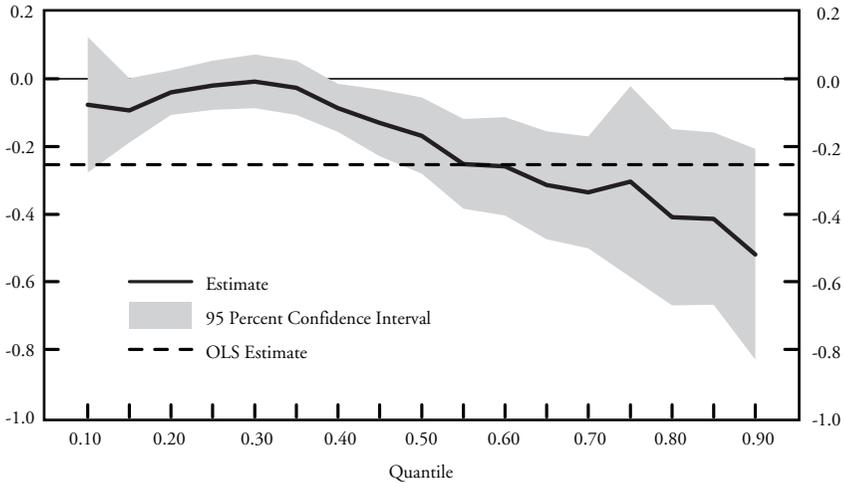
Notes: No. of firms = 305. In each specification, the dependent variable is $\Delta_{12} \log \text{PPI}_j^{2008}$, a weighted-average of the 12-month log-difference of the industry-adjusted item-level prices of firm j in 2008. Explanatory variable is $\log \text{LIQ}_j^{2006}$, where LIQ_j^{2006} denotes the average ratio of liquid assets to total assets of firm j in 2006. The solid line shows the estimated marginal effect (dy/dx) of a one-unit change in LIQ_j^{2006} on $\Delta_{12} \log \text{PPI}_j^{2008}$, evaluated at the 0.05, 0.06, . . . , 0.94, 0.95 quantiles of $\Delta_{12} \log \text{PPI}_j^{2008}$. All specifications include a constant (not reported). The 95-percent pointwise confidence interval is based on a heteroscedasticity-consistent asymptotic covariance matrix.

external finance fall by less in response to economic downturns associated with heightened financial distress. These results are buttressed by the complementary analysis at the item-level of the PPI, which shows that during the recent financial crisis, firms with greater financial exposure—as indicated by low levels of internal liquidity prior to the crisis—raised prices significantly relative to their industry average in 2008, compared with firms that are less exposed to changes in financial conditions.

IV.   An Overview of the GSSZ Model

The theory of customer markets, combined with financial market frictions, provides a natural way to understand these empirical findings. In a customer-markets framework (see Phelps and Winter 1970; Bils 1989), firms seek to charge a low price today to increase their future market share. In such an environment, setting a low price today is a form of investment, as firms forgo current profits with the expectation of greater demand and hence greater profits in

the future. For firms in weak financial position, however, such an investment activity can be risky: A firm with low operating profits and very little financial capacity may not be able to meet current expenses due to fixed operating costs or satisfy its current debt obligations. Our empirical evidence implies that liquidity constrained firms actively seek to avoid such risks by maintaining higher prices than their financially sound competitors. In the presence of financial market distortions, changes in macroeconomic conditions that weaken a firm's financial position will lead to an attenuation of downward inflationary pressures, compared with an environment in which firms face no frictions in accessing external finance.

To formalize this intuition, GSSZ develop a tractable quantitative general equilibrium model, which builds on the standard New Keynesian framework where monopolistically competitive firms face downward-sloping isoelastic demand curves and set prices optimally. In the absence of either customer markets or nominal price rigidities, the model delivers the standard result, whereby firms set price as a constant markup over marginal cost and where the size of the markup is a decreasing function of the degree of price elasticity. Introducing nominal rigidities implies that firms become forward looking and set prices as a constant markup over a present discounted value of future marginal costs. Because marginal costs are systematically related to the size of the output gap, this gives rise to the standard New Keynesian Phillips curve, in which inflation is an increasing function of current and expected future output gaps. In the absence of cost-push shocks to inflation, the New Keynesian model implies, therefore, a positive relationship between economic activity and inflation.

Ravn, Schmitt-Grohe and Uribe (2006) introduce customer markets into an otherwise standard New Keynesian model by assuming that household consumption is subject to habit formation at the level of an individual good. Specifically, they assume that households' current demand for a given good is an increasing function of a stock-based measure of past consumption of that good. The habit is modeled as a "keeping up with the Joneses" phenomenon and is assumed to be external to the household. As a result, households take the habit stock as given and do not internalize the effect of their own consumption on future demand.[27]

Firms, on the other hand, recognize that if they lower prices and increase output today, such a move will also boost future demand. They, therefore, set their current price so that the present value of the marginal revenue stream is equal to the present value of marginal costs resulting from these output gains. In such an environment, firms' pricing decisions become forward looking even in the absence of nominal price rigidities. With the addition of nominal rigidities, the Ravn, Schmitt-Grohe and Uribe (2006) formulation of customer markets strengthens the conclusion that inflation and output will comove positively in the absence of cost-push shocks.

GSSZ introduce an additional element into this framework: the possibility that firms are financially constrained and hence view price reductions as a risky activity that increases the likelihood of having to tap—possibly prohibitively—costly external finance. To avoid this risk, financially constrained firms seek to raise prices relative to their unconstrained counterparts in response to reduced demand or a tightening of financial conditions. To maintain tractability, GSSZ assume a production and financing environment, whereby firms set prices—and hence commit to selling output—before knowing their cost structure. They also allow for fixed costs of production and idiosyncratic cost shocks, factors that create the possibility that some fraction of firms will incur operating losses.

For simplicity, GSSZ abstract from corporate savings decisions by assuming that firms with positive profits pay out cash as dividends, while those incurring losses must raise costly external finance to cover the shortfall. The cost of external equity finance is set at a constant fraction of the amount equity raised.[28] The presence of idiosyncratic cost shocks implies that firms have heterogeneous outcomes, while the assumption of no corporate savings implies that this heterogeneity has no persistent effects—that is, firms with identical production and financing costs will ex ante choose the same price and level of production.[29] The presence of this financial friction has important implications for aggregate price dynamics: Given fixed costs of production, revenues are less likely to cover costs in periods of falling demand, in which case a firm may ex post need to rely on costly external finance; because firms recognize this risk ex ante, they act cautiously by maintaining high prices during the downturn.

Beyond these two elements, customer markets and costly external finance, the GSSZ model is equivalent to the standard New Keynesian model that abstracts from capital accumulation. Labor is therefore the only input to production. In the absence of nominal wage rigidities, the New Keynesian model may be expressed as a familiar three-equation system, consisting of an IS curve derived from the household's Euler equation; a Phillips curve derived from the optimal price-setting and production decisions of firms; and a monetary policy rule that governs the response of nominal interest rates to inflation and output. The New Keynesian model that underlies the GSSZ framework expands upon this three-equation system by also allowing for nominal wage rigidities, which introduces a wage Phillips curve.

GSSZ first study a model in which firms are homogeneous with respect to their cost structure and face the same external financing costs. In a version of the model calibrated to capture the extreme degree of financial distress experienced at the nadir of the crisis in late 2008, GSSZ show that an exogenous decline in demand leads to a significant contraction in output and an increase in inflation. In addition, financial shocks—modeled as an exogenous temporary increase in the cost of external finance—cause a sharp and immediate rise in inflation that is followed by a significant and protracted decline in output.

As shown by GSSZ, financial shocks act like cost-push shocks, in the sense that they directly shift the Phillips curve upward and lead to higher inflation at a given level of resource utilization. This mechanism resembles the "cost channel" emphasized by Barth and Ramey (2001), in which firms rely on costly external finance to fund their working capital needs. In that framework, financial shocks resemble exogenous cost-push shocks that increase marginal costs at a given level of output. Although present in the GSSZ model, the cost channel is not the primary mechanism through which financial frictions influence aggregate supply. Rather, as financial conditions tighten, firms begin to discount the future more heavily and put less weight on future gains in market share—relative to current profits— when setting their prices. By discounting the future more, firms,

in effect, exploit the captive nature of their existing customer base, which is relatively price insensitive in the short run.

Importantly, the interaction of customer market with financial frictions also creates an endogenous dynamic that is typically absent in the cost channel framework: As firms seek to raise prices in response to an increase in the cost of external finance, markups increase and output falls— in turn, this leads to a further deterioration of firms' financial positions and further increases in prices. The model thus implies a financial accelerator mechanism, which amplifies the original downturn. In contrast to the financial accelerator models that work through investment demand (see Bernanke, Gertler and Gilchrist 1999), the financial mechanism in GSSZ impinges on aggregate supply and introduces a negative comovement between inflation and output in response to demand and financial shocks.

GSSZ extend this framework to a two-sector environment, which allows them to study the heterogeneous behavior of firms facing a differing degree of financial constraints. In response to an adverse financial shock, this model implies that financially constrained firms raise prices, while their financially unconstrained counterparts lower prices. This divergence in sectoral (relative) prices leads to a divergence in sectoral output and a contraction in overall economic activity. In effect, financially strong firms are able to take advantage of their financially weak competitors and gain market share at their expense. The ensuing downturn leads to a further reduction in the profitability of financially weak firms and further rounds of price increases, an adverse feedback loop that generates substantial amplification effects, relative to a model in which firms face financial frictions but do not operate in customer markets.

V.   Implications of Financial Frictions
and Customer Markets

In this paper we explore the robustness of these findings in a number of dimensions. We start with the basic two-sector model but recalibrate it to an environment in which firms in one sector are financially unconstrained, while firms in the other sector face a relatively moderate degree of financial distortions.[30] Such a setup is more likely to reflect normal financial market conditions and thus provides

a useful benchmark for gauging the role of financial frictions and customer markets in cyclical fluctuations.

In contrast to GSSZ, who rely on differential fixed costs of production to generate heterogeneity across firms, we assume fixed costs are equalized across the two sectors. Heterogeneity in our case arises from differences in dilution costs associated with external equity finance: These costs are assumed to be zero for firms in the unconstrained sector and positive for firms in the constrained sector.[31] Specifically, we set the equity dilution cost parameter to 0.3, the non-crisis baseline value used by GSSZ. This parametrization implies an expected external finance premium of 12 percent for the constrained firms in the economy. However, because this premium matters only for one-half of the firms in the economy, the effective economywide premium on external funds is 6 percent, a value substantially below that used by GSSZ to calibrate their baseline model to a non-crisis situation.

In addition to calibrating the model to a significantly lower overall degree of financial frictions, we also assume substantially lower costs of changing nominal output prices than GSSZ to highlight the fact that price stickiness is not the main driving force in the model. Specifically, we set the quadratic adjustment cost coefficient of changes in goods prices equal to 3.0, significantly less than the value of 10 assumed by GSSZ. It is worth noting that even the latter value is already substantially lower than the degree of price stickiness implied by the Bayesian estimation of the standard New Keynesian DSGE models (Guerrón-Quintana and Nason 2013). We do, however, maintain the assumption of sticky wages and set the quadratic cost coefficient on nominal wage changes to 30, the same as GSSZ. Finally, the monetary policy rule in the baseline calibration follows that adopted by GSSZ, who allow the nominal interest rate to respond to inflation and lagged interest rates but place no weight on output stabilization. Specifically, under the baseline calibration in GSSZ, the long-run coefficient on inflation is set equal to 1.5 and the interest-rate smoothing coefficient to 0.75.

Given this calibration, we consider the effect of persistent, but temporary, demand and financial shocks. The two shocks are assumed to follow first-order autoregressive processes, with the persistence

coefficient of 0.9 at a quarterly rate. As discussed by GSSZ, the demand shock causes a direct shift in the marginal utility of consumption. This shock is calibrated to generate a standard deviation of 1.25 percent in consumption growth. The financial shock, by contrast, induces a direct increase in the cost of external finance. Following the baseline calibration in GSSZ, the size of this shock is set so that equity dilution costs in the financially constrained sector increase from 0.3 to 0.37 upon impact. In turn, this implies an increase in the expected external finance premium for the constrained firms of 3 percentage points, or 1.5 percentage points for the economy as a whole; this latter value is roughly in line with the variability of U.S. corporate bond credit spreads, measured by their standard deviation over the past half a century.

We now present our model simulations. Subsection V.i considers the effects of demand and financial shocks in a baseline two-sector model that is calibrated as described above; these benchmark results may be considered as a robustness exercise vis-á-vis the findings reported by GSSZ. In subsection V.ii, we explore the implications of alternative monetary policy rules for macroeconomic outcomes. This exercise highlights the difficult policy dilemma implied by models, in which firms' pricing-setting behavior is influenced by their joint consideration of market shares and current and future financing needs.

V.i   *Demand and Financial Shocks in the Baseline Model*

Chart 10 shows the effect of a temporary, but persistent, expansion in demand. The solid lines represent impulse responses of selected variables from the two-sector model, in which firms in one sector face financial constraints (indicated by FC), while those in the other sector are financially unconstrained (indicated by NFC). The dashed lines, by contrast, depict impulse responses from a symmetric model, in which firms in neither sector are subject to costly external finance. The upper panels of the chart show the effect on aggregate output (Panel A), the aggregate markup, measured as the weighted average of sectoral markups (Panel B) and aggregate inflation (Panel (C)). The lower panels of the chart display the effect of such a demand shock on sectoral output (Panel D), sectoral relative prices (Panel (E)), and the nominal interest rate (Panel F).

Chart 10
Macroeconomic Implications of a Demand Shock
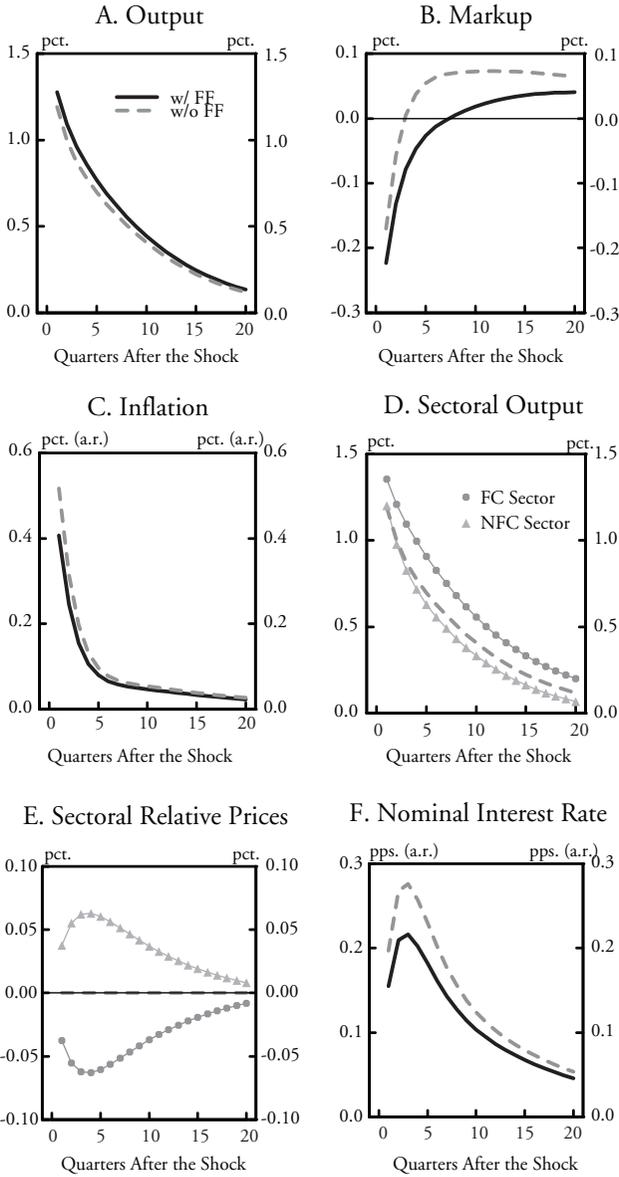
A. Output

B. Markup

C. Inflation

D. Sectoral Output

E. Sectoral Relative Prices

F. Nominal Interest Rate

Notes: The panels of the chart depict the model-implied responses of selected variables to a temporary expansionary demand shock: w/ FF = responses implied by the two-sector model with financial frictions; and w/o FF = responses implied by the one-sector model without financial frictions. In the two-sector model, FC denotes the financially constrained sector and NFC denotes the financially unconstrained sector; aggregate responses are computed under the assumption that the two sectors are of equal size.

In the model with financial frictions, the expansionary demand shock leads to a substantial increase in aggregate output (about 1.25 percent on impact) but only a mild increase in inflation (less than 0.5 percent at an annual rate). Consistent with the New Keynesian mechanism that is embedded in the model, this positive demand shock also implies a sizable reduction in the average markup (almost 0.25 percent). The lower panels illustrate the economic mechanism that works through the interaction of financial frictions and customer markets. As overall output expands, firms in the financially constrained sector face improved financial conditions and become more forward looking. Accordingly, they lower prices relative to the aggregate price level, in an effort to increase their customer base. As a result, firms in the financially constrained sector gain market share at the expense of their unconstrained competitors.

In the model without financial frictions, the expansionary demand shock also leads to a sizable increase in aggregate output. Indeed, the difference in the response of output between the two models is very small, a result that highlights the modest amplification effects of financial frictions on output in response to demand shocks in an environment where the overall degree of financial distortions is relatively small. In contrast, the difference in the response of inflation between the two models is appreciably larger. This difference is consistent with the results of GSSZ, who show that financial frictions in a customer markets framework significantly attenuate inflation dynamics when the economy is perturbed by demand shocks.

As shown in the chart's lower panels, sectoral prices respond symmetrically in the model without financial distortions—implying no change in sectoral relative prices—and the sectoral response of output is the same as the aggregate response due to the assumed symmetry of the two sectors. And finally, because the monetary authority is responding to a larger increase in inflation, the increase in the nominal interest rate is greater in the model without financial frictions relative to the model with financial frictions.

Chart 11 traces out the effects of a financial shock in this environment. Recall that the financial shock is modeled as a temporary, but persistent, increase in the cost of external finance for firms in

Chart 11
Macroeconomic Implications of a Financial Shock

A. Output

pct.   pct.

0.0	0.0
-0.1	-0.1
-0.2	-0.2
-0.3	-0.3
-0.4	-0.4

w/ FF
w/o FF

0   5   10   15   20
Quarters After the Shock

B. Markup

pct.   pct.

0.4	0.4
0.3	0.3
0.2	0.2
0.1	0.1
0.0	0.0

0   5   10   15   20
Quarters After the Shock

C. Inflation

pct. (a.r.)   pct. (a.r.)

0.7	0.7
0.6	0.6
0.5	0.5
0.4	0.4
0.3	0.3
0.2	0.2
0.1	0.1
0.0	0.0

0   5   10   15   20
Quarters After the Shock

D. Sectoral Output

pct.   pct.

0.5	0.5
0.0	0.0
-0.5	-0.5
-1.0	-1.0

● FC Sector
▲ NFC Sector

0   5   10   15   20
Quarters After the Shock

E. Sectoral Relative Prices

pct.   pct.

0.3	0.3
0.2	0.2
0.1	0.1
0.0	0.0
-0.1	-0.1
-0.2	-0.2
-0.3	-0.3

0   5   10   15   20
Quarters After the Shock

F. Nominal Interest Rate

pps. (a.r.)   pps. (a.r.)

0.3	0.3
0.2	0.2
0.1	0.1
0.0	0.0

0   5   10   15   20
Quarters After the Shock

Notes: The panels of the chart depict the model-implied responses of selected variables to a temporary increase in the time-varying equity dilution costs: w/ FF = responses implied by the two-sector model with financial frictions; and w/o FF = responses implied by the one-sector model without financial frictions. In the two-sector model, FC denotes the financially constrained sector and NFC denotes the financially unconstrained sector; aggregate responses are computed under the assumption that the two sectors are of equal size.

the financially constrained sector. Because firms in the other sector face frictionless financial markets, this is an asymmetric shock that directly affects firms in the constrained sector by boosting the cost of external funds. It also affects firms in both sectors indirectly through aggregate dynamics at work in general equilibrium.

Consistent with the notion that financial disturbances resemble cost-push shocks, a financial shock in our environment leads to a substantial contraction in aggregate output (almost 0.4 percent on impact), a rise in the aggregate markup, and a sharp increase in inflation (more than 0.6 percent on impact). Although nominal output prices are quite flexible, the model generates persistent countercyclical markups and, therefore, a persistent contraction in output through the customer markets mechanism. In the absence of nominal price rigidities, the model would produce a onetime burst in inflation in response to such a financial disturbance. In our calibration—despite the shock's persistent effects on the aggregate markup and output— inflation subsides within five quarters after the initial impact of the shock, a result that underscores the low level of nominal price rigidities imposed on the model. It is also worth noting that in the standard New Keynesian framework, where nominal rigidities are the sole cause of variation in the markup, inflation responds to the present discounted value of current and expected future markups. As a result, these models typically imply that inflation is equally, if not more, persistent than markups and output.

The sectoral responses displayed in the bottom panels of the chart highlight the model's main mechanism: In response to a deterioration in financial conditions, financially constrained firms increase prices relative to their financially unconstrained competitors. These results show how the calibrated model can qualitatively capture our main empirical findings, which indicate that a tightening of financial conditions induces a significant heterogeneity in the response of firm-and industry-level prices.

In the model, financially constrained firms raise prices to avoid the risk of using costly external finance. Financially unconstrained firms respond by reducing prices to undercut their constrained competitors. As a result, sectoral output of financially constrained firms

contracts significantly more than overall output, while output of the financially unconstrained sector expands notably. As financially constrained firms lose their market share, they also see their habit stocks erode. In turn, this leads to lower output and lower profitability in the financially constrained sector, impelling these firms to maintain persistently high prices. These dynamics imply that the divergence in sectoral prices will persist long after inflation pressures have subsided, a result consistent with our firm-level empirical findings, which show that differences in firms' 2006 liquidity positions had a highly persistent effect on cumulative inflation over the subsequent six years.

V.ii   Monetary Policy Implications

As illustrated above, the combination of customer markets and financial market frictions fundamentally alters inflation and output dynamics, relative to the canonical New Keynesian framework. Specifically, the response of inflation to a demand shock is significantly attenuated, and inflation and output exhibit a negative comovement when the economy is hit by an adverse financial shock. To better understand the monetary policy implications of these new mechanisms, we now consider how the conduct of monetary policy—formalized vis-á-vis an inertial interest-rate rule—influences dynamics of such an economy.

Recall that in our baseline calibration, the nominal interest rate set by monetary authorities responds only to inflation and its own lag. The long-run response coefficient on inflation is set equal to 1.5, while the coefficient governing the degree of interest-rate smoothing equals 0.75. We consider three alternative policy rules in our experiments. The first, which can be thought of as a "strong" inflation targeting policy, increases the coefficient on inflation from 1.5 to 3.0. The second maintains the long-run inflation coefficient at 1.5 but adds an output growth term to the interest-rate rule, with the response coefficient of 0.5.[32] The third, which can be termed as a "weak" inflation targeting policy, also includes the output growth term with the coefficient of 0.5 but lowers the response coefficient on inflation to 1.1.

In Chart 12, Panels A show the responses of output and inflation to demand shocks; Panels B show the corresponding responses to

Chart 12
Baseline versus Alternative Monetary Policy Rules

A. Macroeconomic Implications of a Demand Shock

Baseline vs. Alternative 1	Baseline vs. Alternative 2	Baseline vs. Alternative 3

Baseline Output Alternative Output Baseline Inflation (a.r.) Alternative Inflation (a.r.)

B. Macroeconomic Implications of a Financial Shock

Baseline vs. Alternative 1	Baseline vs. Alternative 2	Baseline vs. Alternative 3

Baseline Output Alternative Output Baseline Inflation (a.r.) Alternative Inflation (a.r.)
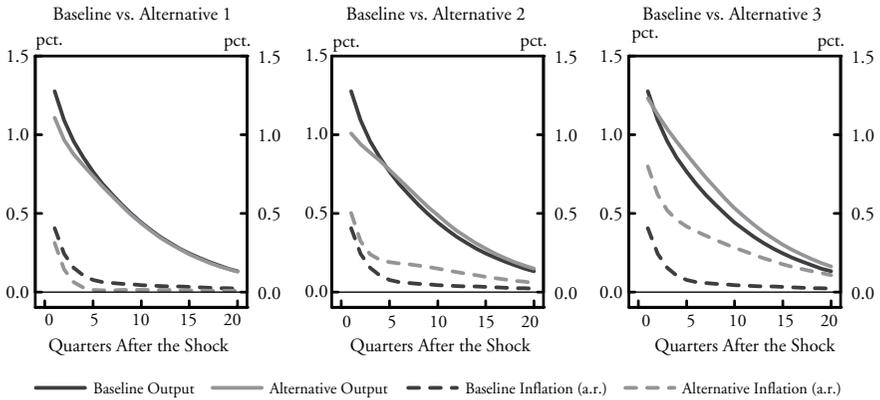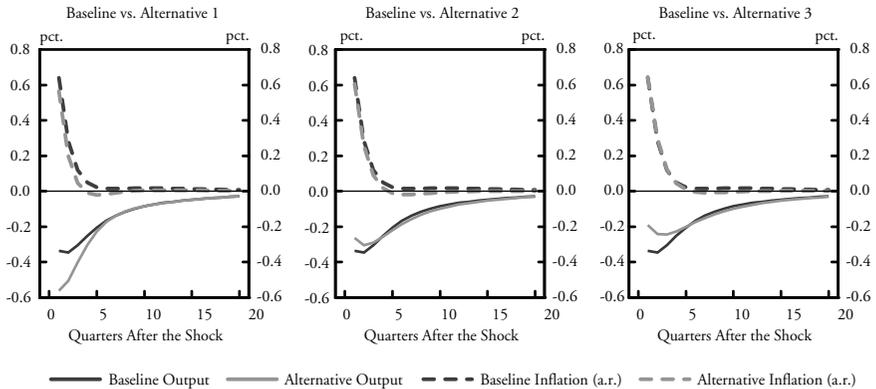
Notes: The A panels of Chart 12 depict the responses of output and inflation implied by the two-sector model with financial frictions to a temporary expansionary demand shock; the B panels depict the corresponding responses to a temporary increase in the time-varying equity dilution cost. Baseline = responses implied by the baseline calibration, under the interest-rate rule with weights of 1.5 on inflation and zero on output growth; Alternative 1 = responses implied by the baseline calibration, under the interest-rate rule with weights of 3.0 on inflation gap and zero on output growth; Alternative 2 = responses implied by the baseline calibration, under the interest-rate rule with weights of 1.5 on inflation and 0.5 on output growth; and Alternative 3 = responses implied by the baseline calibration, under the interest-rate rule with weights of 1.1 on inflation gap and 0.5 on output growth. Aggregate responses are computed under the assumption that the two sectors are of equal size.

financial shocks. In response to a demand shock, strong inflation targeting (Alternative 1) succeeds at stabilizing both inflation and output, relative to the baseline policy rule. Although the stabilization gains are fairly modest, such an inflation targeting policy rule

is clearly beneficial from the perspective of a central bank that aims to stabilize the volatility of both inflation and output. While the addition of the output growth term to the baseline policy rule (Alternative 2) does imply more stable output in response to demand shocks, it comes at a cost of more volatile inflation. The weak inflation targeting rule (Alternative 3) also provides a small gain in output stabilization but comes at the obvious cost of a much larger increase in the inflation response, relative to the baseline case. Overall, these results indicate that, relative to the baseline, only the strong inflation targeting policy rule succeeds at improving on both margins when the economy is perturbed by a demand shock.

As discussed above, financial disturbances imply negative comovement between inflation and output, thereby presenting monetary authorities with a nontrivial dilemma in those circumstances. Panels B of Chart 12 illustrate the trade-offs involved. Strong inflation targeting (Alternative 1) provides at best a very small gain in inflation stabilization when the economy is hit by a financial shock—however, it comes at the cost of a much larger contraction in output, relative to the baseline. Alternative 2, which includes the output growth term, succeeds at reducing the volatility of output somewhat, without materially affecting the response of inflation. Most notably, the weak inflation targeting rule appears to offer the best policy response to adverse financial shocks. Under this policy, there is again very little change in the response of inflation relative to the baseline. However, this rule delivers a sizable gain in output stabilization, reflecting the combination of a fairly weak reaction to an increase in inflation along with a robust response to a contraction in output.

In summary, in a model with customer markets and financial frictions—where the degree of financial distortions is relatively modest—an aggressive inflation targeting rule is effective at stabilizing both inflation and output in response to demand shocks. Although an intermediate policy rule that also responds to output growth provides some benefits in terms of output stabilization, it does so at the cost of a larger and more persistent inflation response. A weak inflation targeting rule, in contrast, leads to a much greater instability of inflation, while delivering very little in terms of greater stability of output in return.

When the economy is hit by a financial shock, however, we obtain the exact opposite conclusion. In that case, responding aggressively to inflation is clearly undesirable—such policy produces very little gain in inflation stabilization, while allowing a significant decline in output. Instead, the rather "dovish" policy response implied by the weak inflation targeting rule appears to be best suited to stabilize output, while incurring very little loss on the inflation stability objective. These results highlight the complexities faced by monetary policy makers, who wish to focus on a "one-rule-fits-all" approach to policymaking. They also suggest that there may be substantial gains to policies that are more tailored to the situation at hand, in particular, policies focused on the exact source of the underlying economic shock(s), as well as policies aimed at the exact mechanisms that produce the deviations of inflation and output from their respective targets.

VI.   Conclusion

In this paper, we argue that financial market frictions significantly shape the cyclical dynamics of producer prices. On the empirical front, we provide new evidence, showing that the response of PPI inflation across industries to changes in aggregate financial conditions—as summarized by the Gilchrist-Zakrajšek excess bond premium—depends importantly on an industry-specific indicator of the ease of access to external finance. Specifically, using the Hadlock-Pierce SA-index of the likelihood of financial constraints, we find that inflation declines substantially less in response to a tightening of financial conditions in industries in which firms are more likely to face significant financial frictions. Quantitatively, the differences in the estimated effects are quite large. For industries with a high SA-index—that is, industries in which firms face a high likelihood of financial constraints—inflation is almost completely insensitive to changes in financial conditions. For industries with a low SA-index, in contrast, inflation is estimated to decline about 3 percentage points over the near and medium term in response to a 1 percentage point increase in the excess bond premium.

We complement this evidence with the firm-level analysis of price dynamics during the 2007-09 financial crisis. Using the matched PPI-Compustat data set constructed by GSSZ, we show that pre-crisis

internal liquidity positions of firms had a significant effect on their price-setting behavior during the Great Recessions. Quantile regression analysis focused on firms' pricing behavior in 2008 reveals that the effects of internal liquidity are statistically significant and quantitatively important only for firms that increased prices relative to their industry average; for firms that lowered their industry-adjusted prices during this period, the effect of internal liquidity is economically and statistically indistinguishable from zero. In combination with the original results reported by GSSZ, these results provide strong evidence that financial frictions significantly dampen deflationary pressures in periods of widespread financial distress.

From a theoretical perspective, we adapt the GSSZ framework to assess the implications of demand and financial shocks in a model calibrated to understand the effects of customer markets and financial frictions on inflation and output dynamics over the course of a "normal" business cycle. Consistent with the results documented by GSSZ, the interaction of customer markets with financial frictions implies a significant attenuation of the response of inflation to demand shocks and a strong negative comovement between inflation and output in response to financial disruptions. In addition, the GSSZ model implies that differential access to external finance can rationalize the cross-sectional pricing patterns discussed above: Firms facing more severe financial frictions increase prices in response to financial shocks, while those with an unfettered access to capital markets lower their prices.

The negative comovement between inflation and output implied by the GSSZ model creates a significant policy dilemma for monetary authorities, whose aim is to stabilize both inflation and output fluctuations. In particular, while aggressive inflation targeting may be beneficial when responding to demand shocks, such a policy rule leads to a substantially larger contraction in output in response to financial shocks. A more dovish policy, which puts more weight on output stabilization and significantly less weight on inflation stabilization, provides substantial benefits in limiting the real effects of financial shocks, with virtually no increase in inflation relative to a stricter inflation targeting regime. These results highlight the challenge of applying a specific interest-rate rule in a world where financial market distortions influence firms' pricing behavior.

   The effects of financial frictions and customer markets on economic outcomes are also highly relevant for the current European situation. In related work, Gilchrist, Schoenle, Sim and Zakrajšek (2015a) document that during the recent eurozone crisis, inflation in countries that experienced a significant increase in their borrowing costs declined by less relative to what can be explained by observed output declines. In addition, they develop a multicountry model with cross-border trade flows that features the key aspects of the interaction between customer markets and financial frictions introduced in their first paper. To the extent that the sharp increase in sovereign borrowing costs during the European debt crisis affected the ability of national banking systems to perform effective credit intermediation, the GSSZ mechanism predicts exactly such inflation differentials. Firms operating in financially distressed economies—the euro area periphery—raise prices and lose market share to firms that export from countries not subject to financial distortions—the euro area core. Moreover, by comparing a monetary union arrangement to a flexible exchange rate regime, they come to a policy conclusion that is strikingly similar to that described above: In response to financial disruptions, a one-size-fits-all policy of inflation targeting leads to poor economic outcomes in both the core and periphery countries.

Endnotes

[1]This puzzling behavior of prices is not confined to the business sector. Core consumer prices—measured by the consumer price index (CPI), excluding food and energy—rose at an average annual rate of 1.6 percent since the end of the Great Recession, a surprisingly small amount of deceleration from the 2 percent average annual rate of increase registered during the course of a downturn.

[2]As noted by Llaudes (2005), underlying this argument is the notion that workers who have been unemployed for a relatively short time are the relevant margin for wage adjustment. The longer-term unemployed, by contrast, do not put much downward pressure on wages because these potential workers are disconnected from the labor market.

[3]Another related explanation that has received some attention involves an apparent flattening of the Phillips curve (see Ball and Mazumder 2011; Simon, Matheson and Sandri 2013). However, it has proved difficult to identify structural changes in the economy that could account for the diminished sensitivity of inflation to the level of unemployment.

[4]For example, as pointed out by Coibon and Gorodnichenko (2015), explanations involving the short-term unemployment rate as the relevant measure of economic slack also imply an absence of deflationary pressures in wages, which is at odds with the data. Moreover, Kiley (2014) shows, using regional variation in short-term and long-term unemployment rates, that these two measures of slack exert very similar downward pressure on consumer price inflation. With regards to the well-anchored expectations hypothesis, Coibon and Gorodnichenko (2015) document that the survey-based measures of household expectations, which they argue are a better proxy for firms' inflation expectations than professional forecasts, were not fully anchored during this period and were very sensitive to swings in oil prices. Empirical support for less-than-fully anchored inflation expectations in the United States, as well as in the euro area, and the United Kingdom, is also provided by Galati, Poelhekke and Zhou (2011), who find that sensitivity of expectations measures extracted from financial asset prices (inflation-index bonds and inflation swaps) to news about inflation and other macroeconomic developments increased notably during the financial crisis. While the cause underlying the increased sensitivity of inflation expectations to incoming economic news during the crisis remains unclear, a possibility exists that the massive monetary stimulus delivered through both conventional and unconventional policy measures may have undermined investors' confidence in the ability of monetary authorities to keep inflation at target over the long run.

[5]In these models, financial frictions affect the firms' pricing behavior through the risky working capital constraint because firms must finance a fraction of their intermediate inputs at the (nominal) interest rate that is expected to prevail during the period in which production takes place (see Christiano, Gust and Roldos 2004; Christiano, Eichenbaum and Evans 2005; Ravenna and Walsh 2006).

[6]The Full Employment and Balanced Growth Act of 1978—commonly known as the Humphrey-Hawkins Act—established price stability and full employment as national economic policy objectives.

[7]We use the widely tracked S&P Goldman Sachs commodity index (GSCI) to measure general price movements in commodity markets. The GSCI is a world-production weighted index of a diverse set of commodities, with weights equal to the average quantity of production of each commodity in the index. However, the GSCI has a fairly high exposure to the energy sector and, as a result, comoves closely with oil prices.

[8]The six-digit NAICS PPI data are published by the BLS. Industry-level industrial production data are published by the Federal Reserve only at the four-digit NAICS level (see Industrial Production and Capacity Utilization–G.17 statistical release). Industrial production indexes at the higher level of disaggregation (five-digit and six-digit NAICS level) are confidential because of a small number of production units in many of these narrowly defined industries.

[9]As detailed in their paper, GSSZ construct a novel data set using micro-level data from two sources: (1) item-level (confidential) producer price data underlying the PPI; and (2) firm-level income and balance sheet data from the Standard & Poor's Financial Services LLC Compustat.

[10]Industrial production indexes are not available for the full set of six-digit NAICS industries. At such a fine level of disaggregation, there are in some cases an insufficient number of production units to construct a meaningful estimate of the index. In those instances, the staff at the Federal Reserve Board aggregates the underlying data across several of such closely related industries. In our matching algorithm, we assigned such industrial production data to all the six-digit industries in the index.

[11]See, for example, Adrian and Shin (2010) and Adrian, Etula and Muir (2014).

[12]All specifications include industry (six-digit NAICS) fixed effects and are estimated by OLS, given the long time-series dimension of our panel. In this context, statistical inference is complicated by the fact that the forecast errors will be serially correlated up to order h because of the overlapping nature of the data and by the fact that errors are likely to exhibit a complex pattern of cross-sectional dependence. To ensure that statistical inference is robust to the presence of arbitrary cross-sectional dependence, we compute the covariance matrix of the regression coefficients using a nonparametric covariance matrix estimator proposed by Driscoll and Kraay (1998), which produces heteroscedasticity- and autocorrelation-consistent standard errors that are robust to very general forms of cross-sectional and temporal dependence; the Newey-West "lag truncation" parameter—the lag length up to which the residuals may be autocorrelated—is set equal to h.

[13]Beyond that, however, the predictive content of the EBP diminishes notably.

[14]The literature has proposed a number of proxies based on linear combinations of observable firm characteristics (e.g., dividends, leverage, liquidity, profitability,

Tobin's Q) in an effort to identify firms that may be facing financial constraints. These include the investment-cash flow sensitivities of Fazzari, Hubbard and Petersen (2000); the Kaplan and Zingales (1997) KZ-index of financing constraints due to Lamont, Polk and Saa-Requejo (2001); the cash flow sensitivity to cash of Almeida, Campello and Weisbach (2004); the Whited and Wu (2006) index of financing constraints; and a variety of different sorting criteria based on observable firm characteristics, such as whether a firm is paying dividends (Fazzari, Hubbard and Petersen 1988), firm size (Gertler and Gilchrist 1994), or if a firm has a credit rating (Whited 1992; Gilchrist and Himmelberg 1995).

[15]The exact formula for the SA-index is

$$\text{SA}_{j,t} = -0.737 \times \text{logSIZE}_{j,t} + 0.043 \times (\text{logSIZE}_{j,t})^2 - 0.040 \times \text{AGE}_{j,t},$$

where $\text{SIZE}_{j,t}$ denotes inflation-adjusted (in \$2004) total assets of firm j in year t and $\text{AGE}_{j,t}$ is the age of the firm, defined as the number of years the firm is listed with non-missing stock price data in Compustat. In calculating the index, Hadlock and Pierce (2010) winsorize total assets at \$4.5 billion and age at 37 years. They show that this simple and intuitive relation between firm size and age is very robust and accurate in identifying financially constrained firms, with smaller values of the index indicating a smaller likelihood of being financially constrained.

[16]Another advantage of the SA-index is that it is based on a sample of firms that is representative of the entire U.S. nonfinancial corporate sector. In contrast, most other such indicators are based on firms sampled exclusively from the manufacturing sector.

[17]The number of observations used to calculate the industry-specific medians of the SA-index at the four-digit NAICS level differs significantly across industry groups. As a result, all the regression results using the SA-index—reported in the inset boxes of the figures—are based on weighted least-squares, with weights equal to the number of observations used to compute the median SA-index in each four-digit NAICS industry; statistical significance of the reported coefficients is based on the heteroscedasticity-consistent asymptotic standard errors computed according to White (1980).

[18]Moreover, as emphasized by Dynan, Elmendorf and Sichel (2006), the rapid pace of financial innovation since the mid-1980s—namely, the deepening and emergence of lending practices and credit markets that have enhanced the ability of households and firms to borrow and changes in government policy such as the demise of Regulation Q—may have also changed the way economic agents respond to changes in financial conditions.

[19]To be consistent with the sample period used in the estimation, we also recomputed the median SA-index at the four-digit NAICS level using Compustat data over 1985-2013. This change in the sample, however, had a negligible effect on the results.

[20]Also consistent with our full-sample period results, there is no systematic cross-sectional relationship between the standardized factor loadings on EBP and those on commodity price inflation over 1985-2013.

[21]Again, to be consistent with the sample period used in estimation, we re-computed the median SA-index at the four-digit NAICS level using Compustat data over 1973-2007; as before, this change had no effect on our results.

[22]Over this sample period, there is also no systematic cross-sectional relationship between the standardized factor loadings on the EBP and those on commodity price inflation.

[23]In addition to putting pressure on their capital and liquidity positions, a surge in drawdown activity during the crisis can be especially unwelcome from the bank's perspective because of the negative selection effect. For example, Enron Corp. drew heavily on its credit facilities as it spiraled toward bankruptcy. More formal and recent evidence of the negative selection effect comes from Jiménez Zambrano, López, and Saurina (2009), who, using Spanish credit registry data, document that firms near default drew down significantly more funds from their lines during the recent financial crisis, compared with their healthier counterparts.

[24]In particular, the commercial paper market—both asset backed and unsecured—nearly dried up during the 2007-09 crisis (see Covitz, Liang and Suarez 2013).

[25]Kashyap, Lamont and Stein (1994) use the same ratio to investigate the effect of financial factors on the cyclical behavior of inventories during the recessions of the early 1980s.

[26]Generically, the industry-adjusted price changes—denoted by $\Delta_h \log \bar{P}_{j,t}$—are calculated as

$$\Delta_h \log \tilde{P}_{j,t} = \sum_i w_{ij,t} \text{ x } \left[\Delta_h \log P_{ij,t} - \Delta_h \log P_t^{IND} \right],$$

where $P_{i,j,t}$ is the price of item i produced by firm j in month t, and P_t^{IND} is the corresponding price index at the two-digit NAICS level; the summation is across all goods i produced by firm j and $0 < w_{ij,t} \leq 1$ is the relative weight of good i within the total shipments of firm j.

[27]See Nakamura and Steinsson (2011) for the analysis of firms' pricing-setting behavior implied by good-specific internal habits.

[28]The assumption of equity as a sole source of external finance is not as restrictive as it may seem at first glance. As shown by Stein (2003), other forms of costly external finance reflecting departures from the Modigliani-Miller paradigm of perfect capital markets can be replicated by properly parametrized equity dilution costs.

[29]In effect, these assumptions allow the GSSZ to model financial frictions in an environment where firms behave monopolistically but without having to keep track of how a joint distribution of habits and financial positions across firms evolves over time.

[30]As in GSSZ, the two sectors are assumed to be of equal size.

[31]The fixed cost parameter is set to 0.3, the value used by GSSZ, in both sectors. To compensate for the presence of fixed costs in both sectors, we assume firms face a slightly lower degree of returns to scale—0.7 rather than 0.8—as in GSSZ's original calibration. Parameters that govern household preferences and, therefore, determine labor supply, as well as those governing the strength of habits are all calibrated as in GSSZ.

[32]By specifying the rule in which the nominal interest rate responds to output growth—as opposed to the output gap—the monetary authority is assumed to follow a "difference" rule of the type proposed by Orphanides (2003). As emphasized by Orphanides and Williams (2006), such rules are highly successful in stabilizing economic activity in the presence of imperfect information regarding the structure of the economy; moreover, they yield outcomes for the federal funds rate that are very close to those seen in the actual data before the funds rate hit the zero lower bound at the end of 2008.

References

Adrian, T., E. Etula and T. Muir. 2014. "Financial Intermediaries and the Cross-Section of Asset Returns," *Journal of Finance*, vol. 69, no. 6, pp. 2557-2596.

_____, and N. Boyarchenko. 2013. "Intermediary Balance Sheets," Federal Reserve Bank of New York, Staff Report No. 651.

_____, and H.S. Shin. 2010. "Liquidity and Leverage," *Journal of Financial Intermediation*, vol. 19, no. 3, pp. 418-437.

Almeida, H., M. Campello and M.S. Weisbach. 2004. "The Cash Flow Sensitivity of Cash," *Journal of Finance*, vol. 59, no. 4, pp. 1776-1804.

Ball, L., and S. Mazumder. 2014. "A Phillips Curve With Anchored Expectations and Short-Term Unemployment," NBER Working Paper No. 20715.

Ball, L.M., and S. Mazumder. 2011. "Inflation Dynamics and the Great Recession," *Brookings Papers on Economic Activity*, vol. 42 (spring), pp. 337-405.

Barth, M.J., and V.A. Ramey. 2001. "The Cost Channel of Monetary Transmission," in *NBER Macroeconomics Annual*, B.S. Bernanke and K. Rogoff, eds., vol. 16, pp.199-249. Cambridge, Mass.: The MIT Press.

Bassett, W.F., M.B. Chosak, J.C. Driscoll and E. Zakrajšek. 2014. "Changes in Bank Lending Standards and the Macroeconomy," *Journal of Monetary Economics*, vol. 62, pp. 23-40.

_____, S. Gilchrist, G.C. Weinbach and E. Zakrajšek. 2014. "Improving Our Ability to Monitor Bank Lending," in *Risk Topography: Systemic Risk and Macro Modeling*, M.K. Brunnermeier and A. Krishnammurthy, eds., pp.149-161. Chicago: The University of Chicago Press.

Bernanke, B.S. 2010. "The Economic Outlook and Monetary Policy," speech at the Federal Reserve Bank of Kansas City Economic Policy Symposium, Jackson Hole, Wyo., Aug. 27, 2010, *http://www.federalreserve.gov/newsevents/speech/bernanke20100827a.htm.*

_____, M. Gertler and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework," in *The Handbook of Macroeconomics*, J.B. Taylor and M. Woodford, eds., pp. 1341-1393. Amsterdam: Elsevier Science B.V.

Bils, M. 1989. "Pricing in a Customer Market," *Quarterly Journal of Economics*, vol. 104, no. 4, 699-718.

_____, and P.J. Klenow. 2004. "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy*, vol. 112, no. 5, pp. 947-985.

Brunnermeier, M.K., and Y. Sannikov. 2014. "A Macroeconomic Model with a Financial Sector," *American Economic Review*, vol. 104, no. 2, pp. 379-421.

Campello, M., E. Giambona, J.R. Graham and C.R. Harvey. 2011. "Liquidity Management and Corporate Investment During a Financial Crisis," *Review of Financial Studies*, vol. 24, no. 6, pp. 1944-1979.

Chevalier, J.A., and D.S. Scharfstein. 1996. "Capital-Market Imperfections and Countercyclical Markups: Theory and Evidence," *American Economic Review*, vol. 86, no. 4, pp. 703-725.

Christiano, L.J., M.S. Eichenbaum and M. Trabandt. 2015. "Understanding the Great Recession," *American Economic Journal: Macroeconomics*, vol. 7, no. 1, pp. 110-167.

_____, _____ and C.L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, vol. 113, no. 1, pp. 1-45.

_____, C. Gust and J. Roldos. 2004. "Monetary Policy in a Financial Crisis," *Journal of Economic Theory*, vol. 119, no. 1, pp. 64-103.

Coibon, O., and Y. Gorodnichenko. 2015. "Is The Phillips Curve Alive and Well After All? Inflation Expectations and the Missing Disinflation," *American Economic Journal: Macroeconomics*, vol. 7, no. 1, 197-232.

Covitz, D., N. Liang and G.A. Suarez. 2013. "The Evolution of a Financial Crisis: Collapse of the Asset-Backed Commercial Paper Market," *Journal of Finance*, vol. 68, no. 3, pp. 815-848.

Del Negro, M., M.P. Giannoni and F. Schorfheide. 2015. "Inflation in the Great Recession and New Keynesian Models," *American Economic Journal: Macroeconomics*, vol. 7, no. 1, pp. 168-196.

Driscoll, J.C., and A. Kraay. 1998. "Consistent Covariance Matrix Estimation with Spatially Dependent Data," *Review of Economics and Statistics*, vol. 80, no. 4, pp. 549-560.

Dynan, K.E., D.W. Elmendorf and D.E. Sichel. 2006. "Can Financial Innovation Help Explain the Reduced Volatility of Economic Activity," *Journal of Monetary Economics*, vol. 53, no. 1, pp. 123-150.

Fazzari, S.M., R.G. Hubbard and B.C. Petersen. 2000. "Investment-Cash Flow Sensitivities are Useful: A Comment on Kaplan and Zingales," *Quarterly Journal of Economics*, vol. 115, no. 2, pp. 695-705.

_____, _____ and _____. 1988. "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, vol. 1, no. 1, pp. 141-195.

Galati, G., S. Poelhekke and C. Zhou. 2011. "Did the Crisis Affect Inflation Expectations?" *International Journal of Central Banking*, vol. 7, no. 1, pp. 167-207.

Gertler, M., and S. Gilchrist. 1994. "Monetary Policy, Business Cycles and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics*, vol. 109, no. 2, pp. 309-340.

Gilchrist, S., R. Schoenle, J. Sim and E. Zakrajšek. 2015a. "Financial Heterogeneity and Monetary Union," Department of Economics Working Paper, Boston University.

_____, _____, _____ and _____. 2015b. "Inflation Dynamics During the Financial Crisis," Finance and Economics Discussion Series Paper No. 2015-12, Federal Reserve Board.

_____, and E. Zakrajšek. 2012. "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, vol. 102, no. 4, pp. 1692-1720.

_____, and C.P. Himmelberg. 1995. "Evidence on the Role of Cash Flow for Investment," *Journal of Monetary Economics*, vol. 36, no. 3, pp. 541-572.

Gordon, R.J. 2013. "The Phillips Curve is Alive and Well: Inflation and the NAIRU During the Slow Recovery," NBER Working Paper No. 19390.

Gottfries, N. 1991. "Customer Markets, Credit Market Imperfections and Real Price Rigidity," *Economica*, vol. 58, no. 231, pp. 317-323.

Guerrón-Quintana, P., and J.M. Nason (2013): "Bayesian Estimation of DSGE Models," in *Handbook of Research Methods and Applications in Empirical Macroeconomics*, N. Hashimzade and M.A. Thornton, eds., pp. 486-512. Northhampton: Edward Elgar Publishing.

Hadlock, C.J., and J.R. Pierce. 2010. "New Evidence on Measuring Financial Constraints: Moving Beyond the KZ Index," *Review of Financial Studies*, vol. 23, no. 5, pp. 1909-1940.

Hall, R.E. 2011. "The Long Slump," *American Economic Review*, vol. 101, no. 2, pp. 431-469.

Hamilton, J.D. 2003 "What is an Oil Shock?" *Journal of Econometrics*, vol. 113, no. 2, pp. 363-398.

_____. 1983. "Oil and the Macroeconomy Since World War II," *Journal of Political Economy*, vol. 91, no. 2, pp. 228-248.

He, Z., and A. Krishnamurthy. 2013. "Intermediary Asset Pricing," *American Economic Review*, vol. 103, no. 2, pp. 732-770.

_____, and _____. 2012. "A Model of Capital and Crisis," *Review of Economic Studies*, vol. 79, no. 2, pp. 735-777.

Ivashina, V., and D.S. Scharfstein. 2010. "Bank Lending During the Financial Crisis of 2008," *Journal of Financial Economics*, vol. 97, no. 3, pp. 319-338.

Jiménez Zambrano, G., J.A. López and J. Saurina. 2009. "Empirical Analysis of Corporate Credit Lines," *Review of Financial Studies*, vol. 22, no. 12, pp. 5069-5098.

Kaplan, S.N., and L. Zingales. 1997. "Do Investment-Cash Flow Sensitivities Provide a Useful Measure of Financing Constraints?" *Quarterly Journal of Economics*, vol. 112, no. 1, pp. 169-215.

Kashyap, A.K., O. Lamont and J.C. Stein. 1994. "Credit Conditions and the Cyclical Behavior of Inventories," *Quarterly Journal of Economics*, vol. 109, no. 3, pp. 565-592.

Kiley, M.T. 2014. "An Evaluation of the Inflationary Pressure Associated With Short- and Long-Term Unemployment," Federal Reserve Board of Governors, Finance and Economics Discussion Series Paper No. 2014-28.

King, R.G., and M.W. Watson. 2012. "Inflation and Unit Labor Cost," *Journal of Money, Credit, and Banking*, vol. 44, no. s2, pp. 111-149.

Koenker, R., and G.W. Bassett. 1978. "Regression Quantiles," *Econometrica*, vol. 46, no. 1, pp. 33-49.

Krueger, A.B., J. Cramer and D. Cho. 2014. "Are the Long-Term Unemployed on the Margins of the Labor Market," *Brookings Papers on Economic Activity*, vol. 48, spring, pp. 229-298.

Lamont, O., C. Polk and J. Saa-Requejo. 2001. "Financial Constraints and Stock Returns," *Review of Financial Studies*, vol. 14, no. 2, pp. 529-554.

Lindsey, D.E., A. Orphanides and R.H. Rasche. 2005. "The Reform of October 1979: How It Happened and Why," Federal Reserve Bank of St. Louis, *Review*, vol. 87, no. 2, pp. 187-235.

Llaudes, R. 2005. "The Phillips Curve and Long-Term Unemployment," ECB Working Paper No. 441.

López-Salido, D., J.C. Stein and E. Zakrajšek. 2015. "Credit-Market Sentiment and the Business Cycle," Federal Reserve Board of Governors, Finance and Economics Discussion Series Paper No. 2015-28.

Nakamura, E., and J. Steinsson. 2011. "Price Setting in Forward-Looking Customer Markets," *Journal of Monetary Economics*, vol. 58, no. 3, pp. 220-233.

_____, and _____. 2008. "Five Facts about Prices: A Reevaluation of Menu Cost Models," *Quarterly Journal of Economics*, vol. 123, no. 4, pp. 1415-1464.

Orphanides, A. 2003. "Historical Monetary Policy Analysis and the Taylor Rule," *Journal of Monetary Economics*, vol. 50, no. 5, pp. 983-1022.

_____, and J.C. Williams. 2013. "Monetary Policy Mistakes and the Evolu-
  tion of Inflation Expectations," in *The Great Inflation: The Rebirth of Modern
  Central Banking*, M.D. Bordo and A. Orphanides, eds., pp. 255–288. Chicago:
  The University of Chicago Press.

_____, and _____. 2006. "Monetary Policy with Imperfect Knowledge," *Journal
  of the European Economic Association*, vol. 4, nos. 2-3, pp. 366-375.

Phelps, E.S., and S.G. Winter. 1970. "Optimal Price Policy Under Atomistic
  Competition," in *Microeconomic Foundations of Employment and Inflation
  Theory*, E.S. Phelps, ed., pp. 309-337. New York: W.W. Norton & Co.

Ravenna, F., and C.E. Walsh. 2006. "Optimal Monetary Policy with the Cost
  Channel," *Journal of Monetary Economics*, vol. 53, no. 2, pp. 199-216.

Ravn, M.O., S. Schmitt-Grohe and M. Uribe. 2006. "Deep Habits," *Review of
  Economic Studies,* vol. 73, no. 1, pp. 195-218.

Simon, J., T. Matheson and D. Sandri. 2013. "The Dog That Didn't Bark: Has
  Inflation Been Muzzled or Was It Just Sleeping?" in *World Economic Outlook:
  Hopes, Realities, and Risks*, pp. 79-95. Washington, D.C.: International Mon-
  etary Fund.

Stein, J.C. 2003. "Agency, Information, and Corporate Investment," in *Hand-
  book of the Economics of Finance*, G.M. Constantinides, M. Harris and R.M.
  Stulz, eds., vol. 1, chap. 2, pp. 111-165. New York: Elsevier Science.

Stock, J.H., and M.W. Watson. 2010. "Modeling Inflation after the Crisis,"
  Macroeconomic Challenges: The Decade Ahead," Federal Reserve Bank of Kansas
  City, Jackson Hole Economic Policy Symposium, Jackson Hole, Wyo., Aug.
  21-23.

White, H. 1980. "A Heteroscedasticity-Consistent Covariance Matrix Estimator
  and a Direct Test for Heteroscedasticity," *Econometrica*, vol. 48, no. 4, 817-838.

Whited, T.M. 1992. "Debt, Liquidity Constraints, and Corporate Investment:
  Evidence from Panel Data," *Journal of Finance*, vol. 47, no. 4, pp. 1425-1460.

_____, and G. Wu. 2006. "Financial Constraints Risk," *Review of Financial Stud-
  ies*, vol. 19, no. 2, pp. 531-559.

Yellen, J.L. 2013. Panel Discussion on "Monetary Policy: Many Targets, Many
  Instruments. Where Do We Stand?" Speech at "Rethinking Macro Policy II,"
  conference sponsored by the International Monetary Fund, Washington, D.C.,
  April 16, *http://www.federalreserve.gov/newsevents/speech/yellen10130416a.htm.*