Do Capacity Constraints Affect the Pass-Through of Monetary Policy to Prices?*

Edvin Ahlander† Niklas Amberg‡ Mathias Klein§

March 25, 2026

Preliminary and incomplete. Please do not cite or circulate.

Abstract

We use granular Swedish micro data to study how capacity constraints at the firm level affect the pass-through of monetary policy to prices. An expansionary monetary policy shock, identified using high-frequency interest rate changes around Riksbank policy announcements, leads to an overall increase in producer prices. However, this average response masks differences between capacity constrained and unconstrained firms. Specifically, we find that constrained firms raise their prices more in response to the shock, but only when many of their closest competitors are also constrained. A multi-industry New Keynesian model with heterogeneous firms and strategic complementarities in price setting reconciles these empirical findings. The model's inflation dynamics crucially depends on the distribution of capacity constrained firms across industries, and delivers a steepened Phillips curve during the recent high inflation period.

Keywords: Capacity constraints, price setting, monetary policy, Phillips curve.
JEL: D21, E22, E32.

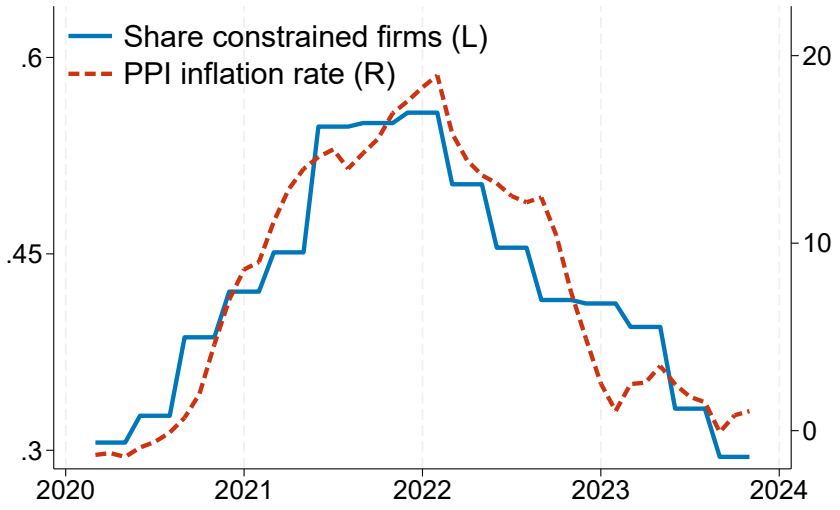
*For valuable comments and suggestions, we thank Michael Bauer, Francesco Bianchi, Drago Bergholt, Martin Blomhoff Holm, Christoph Boehm, Lena Dräger, Isabel Gödl-Hanisch, Per Krusell, Sarah Lein, Jesper Lindé, Kurt Mitman, Anton Nakov (discussant), Gisle Natvik, Omar Rachedi, Soren Ravn, Christina Romer, David Romer, Paolo Surico, Mirko Wiederholt, Peter Zorn and seminar participants at various institutions for helpful comments and discussions. The opinions expressed in this article are the sole responsibility of the authors and should not be interpreted as reflecting the views of Sveriges Riksbank.

†Institute for International Economic Studies, Stockholm University. E-mail: edvin.ahlander@iies.su.se.
‡Sveriges Riksbank, Research Division. E-mail: niklas.amberg@riksbank.se.
§Sveriges Riksbank, Research Division. E-mail: mathias.klein@riksbank.se.

1 Introduction

The recent high inflation period has highlighted the need for a better understanding of firms' price setting behavior and inflation dynamics. An aspect that could influence pricing decisions, and was particularly emphasized during the recent inflation surge, is capacity constraints, i.e. restrictions on firms' ability to expand production in the short term. Figure 1 plots the average share of capacity constrained firms together with the aggregate PPI inflation rate in the Swedish domestic industrial sector between $2020Q2$ and $2023Q4$. As can be seen, the spike in inflation is closely accompanied by a corresponding spike in the share of constrained firms, suggesting that there might be a tight link between the two.

Figure 1: Capacity constraints during the inflation surge



This figure plots for the Swedish domestic industrial sector during the period $2020Q2 - 2023Q4$: (i) the sales-weighted share of capacity constrained firms (blue solid line), and (ii) the aggregate year-on-year PPI inflation rate (red dashed line). Capacity constraints are defined as in the rest of our empirical analysis, see section 2.3 for details.

Although there is a large theoretical literature studying the role of capacity for, e.g., business cycle fluctuations, monetary policy transmission, and inflation dynamics (see, e.g., Christiano, Eichenbaum and Evans, 2005; Alvarez-Lois, 2006; Boehm and Pandalai-Nayar, 2022; and Comin, Johnson and Jones, 2024), empirical evidence on how it affects price setting decisions at the firm level is relatively scarce. In this paper, we aim to fill this gap by leveraging on the micro data underlying the official Swedish producer price index and industrial capacity utilization index to compile a unique data set that tracks both the prices and capacity constraints of a rep-

resentative sample of Swedish industrial firms. We combine this data with exogenous changes in the policy rate of the Swedish Riksbank, identified by applying a standard high-frequency approach similar to those used in the recent literature on monetary non-neutrality (see, e.g., Gertler and Karadi, 2015; Hanson and Stein, 2015; and Nakamura and Steinsson, 2018). This allows us to estimate the pass-through of monetary policy to Swedish producer prices, and in particular, how it varies with firm level capacity constraints.

Our empirical results show that an expansionary monetary policy shock leads to a significant and hump-shaped increase in producer prices on average. An exogenous fall in the interest rate by 25 basis points induces a rise in prices of around 1.2 percent over a two-year horizon. However, the average response masks important differences between capacity constrained and unconstrained firms. Whereas constrained firms adjust prices strongly and almost immediately following the shock, the price responses of unconstrained firms remain statistically insignificant throughout the forecast horizon. These findings confirm the evidence on convex supply curves documented by Boehm and Pandalai-Nayar (2022), and suggest that the ability of the central bank to influence inflation via changes in the policy rate crucially depends on the average share of capacity constrained firms in the economy.

Next, we explore how capacity constraints among firms' closest competitors affect their price responses to the monetary policy shock. These could matter for price setting decisions because if the closest competitors are not capacity constrained, and hence raise their prices less following the monetary policy shock, firms may be reluctant to adjust prices in order to not loose out too much in competitiveness. Specifically, for each firm in our sample, we construct a measure representing the sales-weighted share of constrained firms among its competitors, defined as those firms operating within the same narrow industry code. When separating between firms with a high and low share of constrained firms within their industry, we find that the former group displays considerably larger differences in price responses across constrained and unconstrained firms. Specifically, this difference is slightly less than two percentage points when the share of constrained firms within the industry is above 60 percent, while it is statistically insignificant when the share is below 60 percent. Hence, not only the average share of constrained firms in the economy, but potentially also the distribution of constrained firms across industries, matter for the transmission of monetary policy.

To rationalize our empirical findings, we develop a multi-industry New Keynesian model featuring heterogeneous firms and capacity constraints. Relative to previous studies that incorporate capacity constraints into macroeconomic frameworks (see, e.g., Alvarez-Lois, 2006;

Boehm and Pandalai-Nayar, 2022; Comin, Johnson and Jones, 2024), we add one critical model ingredient. In particular, we assume that intermediate inputs are aggregated according to a Kimball (1995) aggregator, which allows for non-constant demand elasticities and thereby strategic complementarities in price setting. This setup preserves the tractability of the standard New Keynesian model, featuring monopolistic competition and CES aggregation, while implicitly capturing strategic interactions between firms operating under imperfect competition.[1] We show that the interplay between capacity constraints and strategic complementarities in our model elevates the price responses of constrained firms in industries with a high share of constrained firms, in line with our empirical results. When eliminating the role of strategic complementarities and resorting to the typical CES aggregator, industry composition influences the differential price responses between constrained and unconstrained firms only to a limited extent.

Finally, we derive the model implications of the interaction between capacity constraints and strategic complementarities for the slope of the aggregate Phillips curve. In our model, both increasing the average share of constrained firms in the economy, and increasing the dispersion of constrained firms across industries while holding the average share fixed, significantly steepens the Phillips curve. During the recent inflation surge, both the average share and the within industry composition of constrained firms changed noticeably, and we show that this elevated the slope by roughly 80 percent. Hence, our model is able to reconcile the sudden shift from a low- to high inflation environment recently experienced in many developing countries. In contrast, the model without strategic complementarities generates considerably smaller variations in the Phillips curve when varying these capacity measures.

The remainder of this paper is structured as follows. Section 2 describes our data, and provides details concerning variable definitions and empirical specifications. Section 3 presents our empirical results. Section 4 describes our model, while section 5 presents model impulse responses and simulation results. Finally, section 6 concludes.

2 Data and Empirical Framework

2.1 Data and sample composition

The analysis is based on two main datasets and several auxiliary datasets. The first main dataset is the micro data underlying the official Swedish producer-price index (PPI), produced by Statis-

[1] Wang and Werning (2022) shows that an appropriately calibrated Kimball (1995) aggregator serves as a good approximation to oligopolistic competition in the context of monetary policy transmission.

tics Sweden, the official Swedish statistics agency. The PPI dataset is of monthly frequency and consists of the prices of all products that enter into the Swedish producer price index, which is a representative sample of domestically produced as well as imported products. Statistics Sweden collects the PPI data by means of a survey that sampled firms are legally required to respond to. The sampling unit is "product offering," which corresponds to a unique firm-product combination.[2] The probability that a product offering is selected for inclusion in the survey is proportional to its production value (a new sample is drawn once per year).[3] For each product offering, we observe the average actual transaction price during the month, the industry to which the product belongs according to the Swedish Standard for Product Classification by Industry (SPIN), and the product offering's weight in the aggregate producer-price index. We restrict the sample to domestically produced industrial products, i.e., products that are produced and sold in Sweden and belong to SPIN sections B (mining) or C (manufacturing). The cleaned PPI dataset spans the period January 2001–March 2024 and constitutes an unbalanced panel with 488,215 observations across 3,356 firms and 10,059 product offerings.

The second main dataset, also from Statistics Sweden, comprises the micro data underlying the aggregate Swedish industrial capacity-utilization series. Statistics Sweden collects these data through a quarterly survey (*Industrins kapacitetsutnyttjande*), which covers firms in the mining and manufacturing sectors. The dataset comprises two key variables. The first is a firm's capacity utilization, defined as the ratio between the firm's actual production level and full production capacity.[4] The capacity-utilization levels reported by firms cannot be lower than zero percent, but they may exceed 100 percent. The reason is that firms are instructed to consider working hours that "may be deemed normal" when assessing their production capacity; firms that produce unusually high levels of output by means of overtime labor should therefore report capacity-utilization levels above 100 percent. The second key variable is the reason why firms operate below full capacity, constructed based on a survey question that asks firms reporting capacity-utilization levels below 100 percent to select one or several of the following pre-specified reasons: lack of high-skilled workers, lack of other workers, lack of intermediate inputs, insufficient demand, production disturbances, and other reasons. The survey samples

[2]Note that a product refers to a specific item for sale, not a product category: for example, iPhone 17 and iPhone 17 Pro both belong to the eight-digit Combined Nomenclature code 85171300 ("Smartphones"), but are two distinct products. A product offering is a specific product sold by a specific firm: firm A's sale of iPhone 17 Pro is, for example, a different product offering than firm B's sale of iPhone 17 Pro.

[3]There are two exceptions: product offerings above a certain cutoff in terms of production value are sampled with certainty, while product offerings of firms with less than 10 million SEK in total annual sales are never sampled.

[4]Full production capacity is defined as the maximum level of production that the firm can achieve with its current machinery and staff under currently prevailing production methods (disregarding seasonal factors like vacations).

all business units in the mining and manufacturing sectors (NACE sections B and C) with at least 50 employees, where a business unit is defined as a firm-industry combination—i.e., it corresponds to the production units within a firm that operate in the same industry segment.[5] We thus have multiple observations per firm and period when firms operate in several industry segments, though fewer than 20 percent of the firms in the data have more than one business unit. The cleaned capacity-utilization data spans the period 1998Q1–2024Q1 and consists of 110,839 observations across 3,546 firms and 4,445 firm-industry combinations.

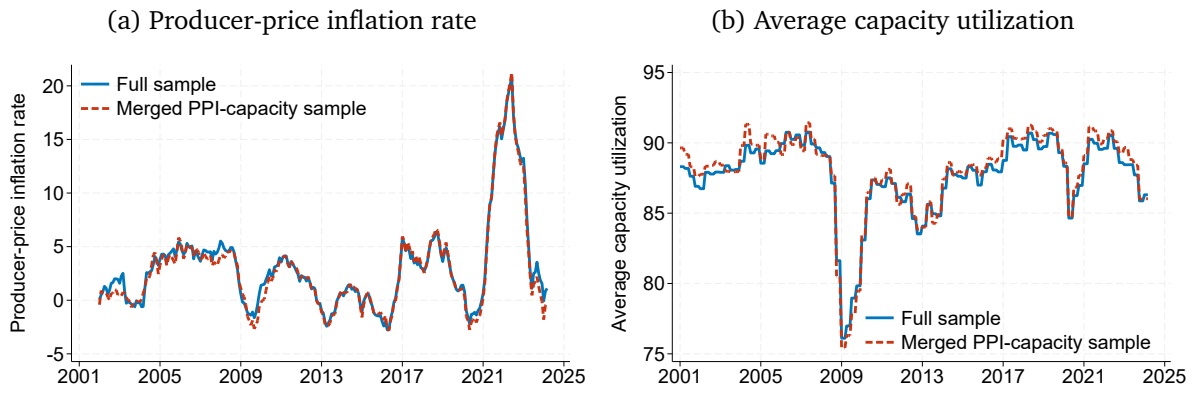
We merge the two main datasets by firm, industry, and month. The firm part of the merge is done by means of the unique identifier (*organisationsnummer*) that belongs to every Swedish firm. Industries are linked by matching the industry classification of the products in the PPI data (SPIN codes) to the corresponding industry codes in the capacity utilization data (NACE codes). We conduct the industry part of the merge at the three-digit level, which gives us a total of 93 distinct industries in the sample. When it comes to the time dimension of the merge, finally, we face the issue that the PPI data is monthly while the capacity-utilization data is quarterly; we deal with this by assuming that the capacity variables do not vary within quarters and assign the same values to all months within each firm-industry-quarter. The resulting matched PPI-capacity utilization dataset is an unbalanced panel of monthly frequency that comprises 245,665 observations across 1,636 firms, and 4,574 product offerings.

The fact that quite a few observations from each dataset are lost in the merge raises the question of whether the merged sample is representative of the full samples in terms of price changes and capacity utilization. To check whether it is, we compare the aggregate producer-price inflation rate and the average level of capacity utilization for two different samples: all observations in the respective datasets and the observations that are part of the merged sample. The two series, shown in Figure 2, are very similar in both cases, which demonstrates that the observations lost in the merge are not a concern for the representativity of the merged sample.

We complement the two main datasets with auxiliary data from three sources. The first is Serrano, an annual firm-level panel that comprises the universe of incorporated firms in Sweden. Serrano is constructed based on data from multiple sources, most importantly the Swedish Companies Registrations Office, to which all Swedish corporations are required to submit annual financial accounting statements in accordance with EU standards. The dataset contains detailed accounting data as well as "demographic" firm data—such as industry codes, location,

[5]Business units with fewer than 50 employees were occasionally included in the capacity-utilization survey prior to 2009, but since then the threshold applies strictly. To ensure that our sample is consistently defined over time, we drop business units with fewer than 50 employees that appear in the data in years prior to 2009.

Figure 2: Representativity of the merged PPI-capacity sample



The producer-price inflation rate is the weighted average of the individual price changes in the micro data, where the weights are the same as those used in the construction of the official producer-price index. The average capacity utilization is the unweighted arithmetic average of the individual capacity-utilization rates in the micro data. The year labels mark the month of January of the respective years.

and age—and spans the period 1998–2022. The second source is *Industrins varuproduktion* (IVP; "The Production of Commodities and Industrial Services"), an annual survey conducted by Statistics Sweden that covers all manufacturing plants with at least 20 employees plus a sample of smaller plants. The data comprise transaction prices and quantities of goods sold at the product-plant level. Third, we collect macroeconomic data from various publicly available sources. The data from Serrano and IVP go into the construction of some of the main explanatory variables, while the Serrano data and the macro data are used to construct control variables, as we explain in detail below.

2.2 Econometric models

The empirical analysis consists of three main steps. First, we estimate the average response of producer prices to monetary policy shocks using the following local-projections model:

$$\ln p_{i,j,k,t+h} - \ln p_{i,j,k,t-1} = \alpha^h_{i,j} + \beta^h \cdot MP_t + \psi^h \cdot \mathbf{X}_{i,j,k,t} + \varepsilon^h_{i,j,k,t}, \tag{1}$$

where $\ln p_{i,j,k,t}$ is the log of the price charged by firm i in month t for product j belonging to three-digit NACE industry k, MP_t is the monetary policy shock in month t, $\alpha^h_{i,j}$ is a firm-product

(i.e., product offering) fixed effect, and $\mathbf{X}_{i,j,k,t}$ a vector collecting additional control variables.[6] The coefficients of interest are the β_h, which capture the average change in producer prices over an h-month horizon following a 100 basis points contractionary monetary policy shock. Standard errors are clustered by firm and period, respectively, to account for serial correlation in the errors within firms, as well as for the fact that the monetary policy shock does not vary across observations within time periods.

Second, we assess how capacity constraints affect the pass-through of monetary policy shocks to producer prices. We do so by interacting the monetary policy shock in equation (1) with an indicator variable for capacity-constrained firms, which yields the following estimating equation:

$$\begin{aligned}\ln p_{i,j,k,t+h} - \ln p_{i,j,k,t-1} = \alpha^h_{i,j} + \beta^h \cdot MP_t \cdot C_{i,k,t-3} \\ + \gamma^h \cdot MP_t + \delta^h \cdot C_{i,k,t-3} + \psi^h \cdot \mathbf{X}_{i,j,k,t} + \varepsilon^h_{i,j,k,t}\end{aligned} \tag{2}$$

where $C_{i,k,t-3}$ is an indicator variable equal to one if firm i operating in industry k is capacity constrained in month $t-3$ and zero otherwise.[7] The effect of a 100 basis points monetary policy shock on product prices over an h-month horizon is given by γ^h for unconstrained firms and $\gamma^h + \beta^h$ for constrained firms. As before, standard errors are double-clustered by firm and time. We also estimate a version of equation (2) that includes time fixed effects (θ^h_t). The benefit of doing so is that the time fixed effects absorb any time-varying shocks common to all firms, which allows us to more credibly identify the causal effects of monetary policy shocks. The drawback, on the other hand, is that the time fixed effects also absorb the monetary policy shock itself, so that the model only identifies the difference between the price responses of constrained and unconstrained firms (β^h)—not the level response for each group.[8] We therefore view the models with and without time fixed effects as complementary.

The key identifying assumption underlying specification (2) is that there are no unobservable firm characteristics that (i) are correlated with the capacity-constraint indicator and (ii) affect the sensitivity of product prices to monetary policy shocks. The second part of the assumption is crucial: firm characteristics that affect prices and are correlated with capacity constraints, but do not affect the sensitivity of prices to monetary policy shocks, are not a concern for the validity

[6]The set of controls comprises twelve lags each of the dependent variable and the main explanatory variable, as well as twelve lags each of the aggregate producer-price index, an index for new orders in industrial firms ("*Industrins orderingång*"), the Bloomberg commodity-price index (all in logs), and the KIX index (a SEK exchange-rate index). We also include calendar month dummies to absorb seasonal patterns in price changes.

[7]As the capacity-utilization data is quarterly, we need to lag the constraint indicator by at least three months to ensure that we always interact the monetary policy shock with a non-contemporaneous value of the indicator.

[8]The time fixed effects also make most of the controls in the vector $\mathbf{X}_{i,j,t}$ redundant: the only controls that remain in the specification with time fixed effects are the twelve lags of the dependent variable.

of the estimates. We therefore conduct extensive robustness checks in which we augment the empirical model with interactions between the monetary policy shock and various firm characteristics that according to the previous literature may affect the sensitivity of product prices to monetary policy shocks, such as financial constraints.

Finally, we test whether the role of an individual firm's capacity constraints in the price response to monetary policy shocks depends on the constraints of the firm's competitors. To this end, we compute the weighted average share of constrained firms in firm i's industry k in period t ($\overline{C}_{i,k,t}$) and then estimate specification (2) separately for firms that operate in industries with high and low shares of constrained firms. More specifically, we classify firm i as operating in a highly constrained industry in period t if the share of constrained firms in its industry k was higher than 60 percent in the previous quarter ($\overline{C}_{i,k,t-3} > 0.6$), which is approximately the 75th percentile in our sample. The difference between the β^h estimates that we obtain from the two subsamples thus capture how the difference in the price response to monetary policy shocks between constrained and unconstrained firms varies with the capacity constraints of their competitors.

As an alternative way of assessing how firm-level capacity constraints interact with industry-level capacity constraints in determining the price sensitivity to monetary policy shocks, we estimate the following triple-differenced specification:

$$\begin{aligned}\ln p_{i,j,k,t+h} - \ln p_{i,j,k,t-1} = \alpha^h_{i,j} + \theta^h_t + \zeta^h \cdot MP_t \cdot C_{i,k,t-3} \cdot \mathbf{1}[\overline{C}_{i,k,t-3} > 0.6] \\ + \beta^h \cdot MP_t \cdot C_{i,k,t-3} + \overline{\beta}^h \cdot MP_t \cdot \mathbf{1}[\overline{C}_{i,k,t-3} > 0.6] \\ + \delta^h \cdot C_{i,k,t-3} + \overline{\delta}^h \cdot \mathbf{1}[\overline{C}_{i,k,t-3} > 0.6] + \psi^h \cdot \mathbf{X}_{i,j,k,t} + \varepsilon^h_{i,j,k,t},\end{aligned} \tag{3}$$

where $\mathbf{1}[\overline{C}_{i,k,t-3} > 0.6]$ is the indicator for industries with high shares of capacity-constrained firms, defined as above. The benefit of this triple-differenced specification—compared to estimating equation (2) separately for industries with high and low shares of constrained firms—is that it allows us to compare the price sensitivity to monetary policy shocks across all possible combinations of firm and industry constraints.

2.3 Variable construction and descriptive statistics

The key variables in the analysis are defined as follows. First, we define firm i operating in industry k as being capacity constrained in month t ($C_{i,k,t} = 1$) if either of two conditions are fulfilled: (i) the firm reports a capacity-utilization level of 100 percent or higher, or (ii) the

firm operates below 100 percent and states at least one of the following reasons for doing so: lack of high-skilled workers, lack of other workers, or lack of intermediate inputs. Our capacity-constraint indicator thus captures whether a firm would be able to increase output in response to higher demand (without the use of overtime labor). The second condition is important, because a firm that operates below full capacity because of, say, insufficient access to intermediate inputs cannot increase output in response to higher demand. One can therefore not determine whether a firm is constrained in its ability to increase output simply by looking at its capacity-utilization level, as previously pointed out by Balleer and Noeller (2023).

Second, we compute the sales-weighted average share of constrained firms in each firm i's industry k using the following leave-one-out definition:

$$\overline{C}_{i,k,t} = \frac{\sum_{\ell \in k, \ell \neq i} y_{\ell,k,t} \cdot C_{\ell,k,t}}{\sum_{\ell \in k, \ell \neq i} y_{\ell,k,t}} \tag{4}$$

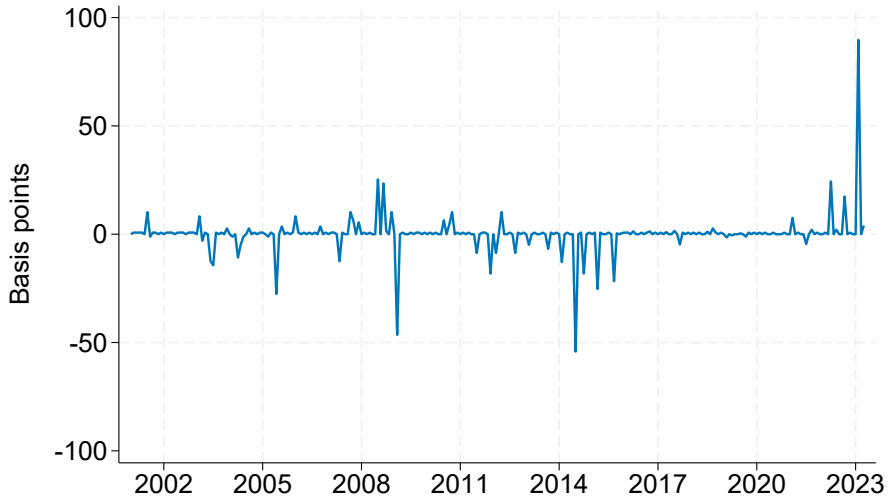
where $y_{\ell,k,t}$ is the sales of firm ℓ that originate from industry k in period t, and $C_{\ell,k,t}$ is the indicator for whether firm ℓ is capacity constrained in period t.[9] $\overline{C}_{i,k,t}$ thus measures the weighted average share of constrained firms in industry k, after excluding firm i. This leave-one-out construction ensures that the measure of the capacity constraints of firm i's competitors is not affected by firm i's own capacity constraints.

Finally, we use the monetary policy shock series from Amberg, Jansson, Klein and Picco (2022), extended up until December 2024. This shock series is constructed by instrumenting the Riksbank's main policy rate with a monetary surprise series obtained from a high-frequency identification strategy similar to those used in the recent literature on monetary non-neutrality (see, e.g., Gertler and Karadi, 2015; Hanson and Stein, 2015; and Nakamura and Steinsson, 2018). More specifically, the monetary surprises are defined as changes in the yield of one-month Swedish Treasury bills on days when the Riksbank announces monetary policy decisions, adjusted for central-bank information effects by means of Jarociński and Karadi's (2020) poor-man's sign restriction. We plot the shock series—that is, the instrumented change in the Riksbank policy rate in month t—in Figure 3. We refer the reader to Amberg, Jansson, Klein and Picco (2022) for further details on the construction of the monetary policy shock series.

We report descriptive statistics for the price and capacity variables in Table 1. The average

[9] We observe sales at the firm-industry-period level in the IVP data, which gives us an exact measure of $y_{\ell,k,t}$. We therefore measure $y_{\ell,k,t}$ using IVP data whenever possible. In case a firm operates in multiple industries but does not appear in IVP, we obtain its total sales from Serrano and allocate it equally across industries. Note that both the IVP data and the Serrano data are annual and that the weights used to compute $\overline{C}_{i,k,t}$ therefore are constant across the quarters within a year. For the lagged measure $\overline{C}_{i,k,t-3}$ used in the empirical analysis, we make sure that the weights are always computed from last year's sales.

Figure 3: The monetary policy shock series



This figure plots the monetary policy shock series at monthly frequency. The year labels mark the month of January of the respective years. The series is constructed following the approach in Amberg, Jansson, Klein and Picco (2022). See the main text for further details.

capacity utilization in the sample is 88 percent, while 40 percent of firms are capacity constrained at any given point in time. The unweighted share of capacity-constrained firms (40 percent) is essentially the same as the weighted share (41 percent), when using the total sales attributed to each firm-industry combination as weights.

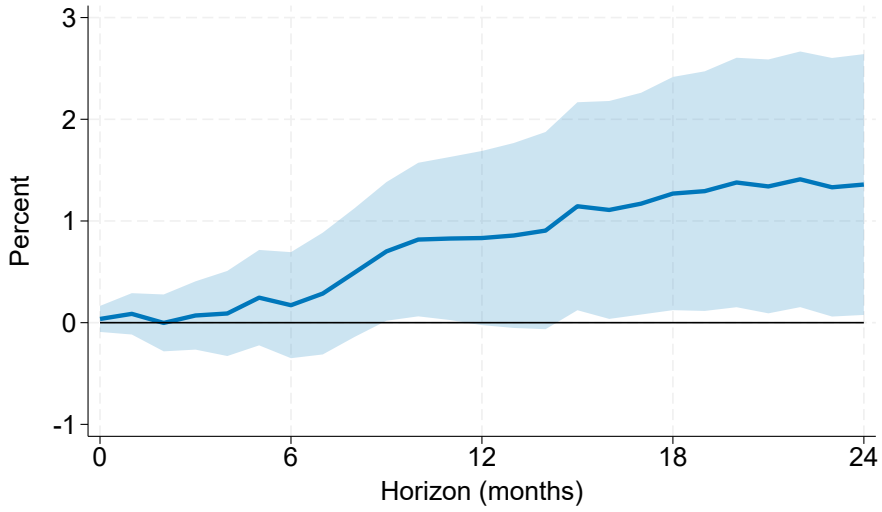
Table 1: Descriptive Statistics

	Mean	Pct. 25	Median	Pct. 75	SD	N
PPI Price Changes	.002	0	0	.0024	.035	171665
Capacity Utilization	.88	.8	.93	1	.15	171665
Capacity Constraint	.4	0	0	1	.49	171665

3 Empirical Results

This section presents the results of the empirical analysis. We scale all reported estimates so that they correspond to the effects of a 25 basis point expansionary monetary policy shock.

Figure 4: The average response of product prices to monetary policy shocks



This figure shows the effect of a 25 basis points expansionary monetary policy shock on product prices, as estimated using equation (1). The shaded area is a 90 percent confidence interval, computed on the basis of standard errors double-clustered by firm and time.

3.1 The average price response to monetary policy shocks

Figure 4 shows the average response of producer prices to an expansionary monetary policy shock over a two-year horizon, as estimated using the model specified in equation (1). The point estimates (solid blue line) show that producer prices increase significantly following expansionary monetary policy shocks, but only with a substantial lag: more specifically, prices do not react within the first two quarters after an expansionary shock, but thereafter increase steadily until the peak of the effect is reached around six quarters after the shock; prices then remain stable at the new, higher level over the remainder of the estimation horizon. The point estimates are for the most part statistically significant from the fourth quarter and onward. The sluggish response of prices to monetary policy shocks evident in Figure 4 is consistent with price stickiness, a cornerstone of New Keynesian macroeconomic models.

The inflationary effect of expansionary monetary policy shocks that we document is qualitatively in line with papers that study the effects of monetary policy shocks on prices using high-frequency identification strategies and data from the U.S. (e.g., Gertler and Karadi, 2015; Jarociński and Karadi, 2020; Bauer and Swanson, 2023). In terms of magnitude, our effect estimates imply that a 25 basis points reduction in the policy rate increases producer prices by around 1.2 percent over a two-year horizon. This is a fairly large estimate compared to many

previous studies, but two things are important two keep in mind in this regard. First, most papers in the previous literature estimate the effects of monetary shocks on consumer prices or the GDP deflator, which are substantially less volatile than producer prices and therefore likely to be less responsive to monetary policy shocks. Second, our effect magnitudes fall within the range of the producer-price estimates found in the previous literature: Holm, Paul and Tischbirek (2021) and Coglianese, Olsson and Patterson (2023), for example, find similarly large effects of monetary policy shocks on producer prices as we do, using Romer and Romer's (2004) identification approach and data from Norway and Sweden, respectively.

We conduct two robustness checks to verify that the micro-level responses of producer prices to monetary policy shocks do not differ meaningfully from the corresponding macro-level responses. First, we re-estimate equation (2) using weighted least squares, where the weights are the same as those used in the construction of the official (aggregate) producer-price index. Second, we estimate the following time-series equivalent of equation (2):[10]

$$\ln p_{t+h} - \ln p_{t-1} = \alpha + \beta^h \cdot MP_t + \psi^h \cdot \mathbf{X}_t + \varepsilon_t^h, \tag{5}$$

where p_t is the aggregate producer-price index for domestically produced goods in SPIN sectors B and C. The respective estimations yield impulse responses, reported in Figure A1 in Appendix A, that are very similar to the unweighted micro-level response in Figure 4.

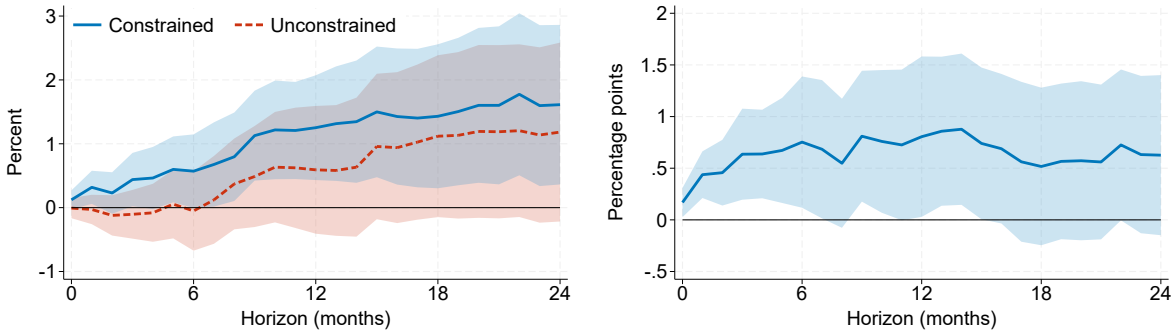
3.2 The role of capacity constraints in the price response to monetary shocks

We now turn to the role of capacity constraints in the transmission of monetary policy shocks to prices. Panel (a) of Figure 5 shows the response of producer prices to an expansionary monetary policy shock among capacity-constrained firms (solid blue line) and unconstrained firms (dashed red line), respectively, as estimated using equation (2) without time fixed effects. The responses show that capacity constraints significantly affect how monetary policy shocks are transmitted to producer prices. Two differences are especially noteworthy. The first concerns the speed with which monetary shocks transmit to prices: constrained firms start to increase prices immediately after policy-rate cuts and then keep increasing them for around five quarters; the prices of unconstrained firms, on the other hand, only start to increase in the third quarter after a rate cut. The second difference is the magnitude and statistical significance of the responses: the price response for constrained firms is statistically significant at virtually all estimation horizons,

[10] In this specification we use Newey West standard errors with lag $h + 1$.

Figure 5: The role of capacity constraints in the response of product prices to monetary shocks

(a) Level responses (without time fixed effects) (b) Relative response (with time fixed effects)



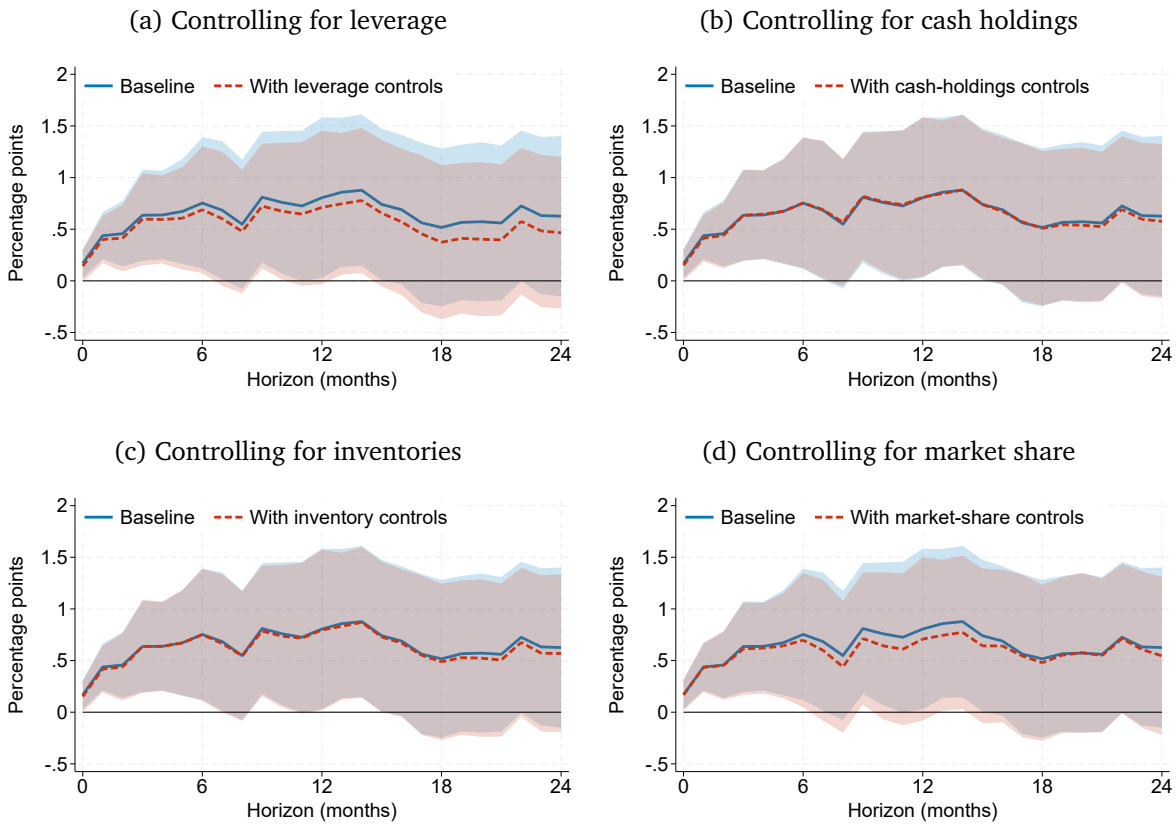
Panel (a) shows the effect of a 25 basis points expansionary monetary policy shock on product prices among capacity-constrained firms (solid blue line) and unconstrained firms (dashed red line), respectively, as estimated using equation (2) without time fixed effects. Panel (b) shows the corresponding relative response of constrained versus unconstrained firms, as captured by the β^h estimates obtained from the estimation of equation (2) with time fixed effects. The shaded areas are a 90 percent confidence interval, computed on the basis of standard errors double-clustered by firm and time.

whereas the response for unconstrained firms is insignificant at all horizons. Moreover, the point estimate is substantially larger for constrained firms at all estimation horizons. Both the speed and the magnitude of the effect of policy-rate changes on product prices thus depends crucially on the extent to which firms face binding capacity constraints.

Panel (b) of Figure 5 reports the corresponding relative price response of capacity-constrained firms and unconstrained firms. The relative responses are estimated using equation (2) with time fixed effects, which means that time-varying shocks common to all firms are controlled for. The difference in the price response in panel (b) is similar to the difference between the level responses in panel (a): prices start to diverge significantly immediately after the monetary shock and then continue to diverge for around five quarters. The peak of the price difference is almost one percentage point, an economically important difference given that the maximum unconditional response of prices is 1.2 percent. From the fifth quarter onward, the prices of unconstrained firms catch up slightly with those of the constrained firms, but the point estimate for the difference remains over half a percentage point throughout the rest of the estimation horizon.

Robustness checks. The key identifying assumption underpinning our interpretation of the

Figure 6: Capacity constraints and the price response to monetary shocks: Robustness checks



This figure shows the scaled estimates of β^h obtained from estimations of (i) the baseline version of equation (2) with time fixed effects (solid blue lines); and (ii) the same model augmented with controls for various firm characteristics (dashed red lines). The firm characteristics enter the estimations both in levels and as interactions with the monetary policy shock. Leverage is measured as the ratio of debt to total assets; cash holdings as the ratio of cash and short-term investments to total assets; inventories as the ratio of the stock of raw materials and finished goods to annual sales; and market share as the share of domestic sales within three-digit industries. The shaded areas are a 90 percent confidence interval, computed on the basis of standard errors double-clustered by firm and time.

results in Figure 5 is that there are no unobserved firm characteristics that (i) are correlated with capacity constraints and (ii) affect the sensitivity of prices to monetary shocks. To corroborate this assumption, we estimate equation (2) augmented with various firm characteristics that the previous literature suggests may affect the sensitivity of prices to monetary policy shocks. The characteristics we consider are leverage (D'Acunto, Liu, Pflueger and Weber, 2018), cash holdings (Gilchrist, Schoenle, Sim and Zakrajšek, 2017), inventories (Kim, 2021; Rodrigues and Willems, 2025), and market power (Baqaee, Farhi and Sangani, 2024), the latter proxied by market shares at the three-digit industry level. We measure each characteristic as of the last

period before the monetary shock and include both its level and its interaction with the shock.

The relative price responses resulting from the estimations with additional controls, reported in Figure 6, are very similar to the baseline relative response in panel (b) of Figure 5. This demonstrates that our baseline results are not due to omitted variable bias stemming from differences in financial constraints, inventory holdings, or market power.

Price responses by bins of the capacity-utilization distribution. We have so far grouped together all firms that operate below full capacity and thereby implicitly assumed that what matters for the transmission of monetary policy to prices is binding capacity constraints, rather than the level of capacity utilization as such. To assess whether this is the case—that is, whether there is a kink in the relative price response at the capacity constraint—we split the unconstrained firms into three bins depending on their capacity utilization levels: the first bin comprises firms with capacity utilization levels between zero and 70 percent, the second bin firms between 70 and 85 percent, and the third bin firms above 85 but below 100 percent (as before, firms operating below 100 percent because of insufficient access to labor or intermediate inputs are classified as capacity constrained). We then estimate equation (2) augmented with indicators for the three bins of unconstrained firms and their respective interactions with the monetary policy shock. We thereby obtain the relative price responses to monetary policy shocks of firms in the four bins, which enables us to determine whether differences in capacity utilization below the constraint matter for the price-sensitivity to monetary policy shocks.[11]

The results of this exercise are reported in Table 2. We show the relative price responses for three different estimation horizons: $h = 6$, $h = 12$, and $h = 18$. The bin containing the firms with the lowest utilization levels (0–70 percent) is the omitted base group; the coefficient estimates are thus the relative price responses for the firms in the respective bins compared to firms in the 0–70 bin. The estimates show that there are no significant differences in the price response to monetary policy shocks across firms in the first three bins—it is only when the capacity constraint becomes binding that the price response increases significantly. This pattern holds for all estimation horizons we consider. The relationship between capacity utilization and the sensitivity of firms' prices to monetary policy shocks is thus non-linear, in line with the evidence on convex supply curves documented by Boehm and Pandalai-Nayar (2022).

[11] To be clear, the four bins are the three with unconstrained firms and the bin with capacity-constrained firms.

Table 2: Relative price responses across the capacity-utilization distribution

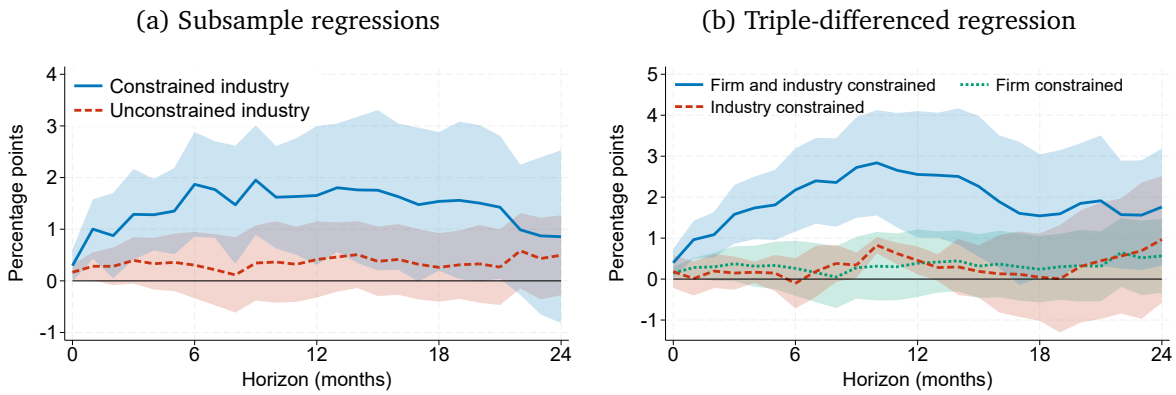
	Estimation horizon (months)		
	$h = 6$	$h = 12$	$h = 18$
$MP_t \cdot \mathbf{1}\left[70 \geq CU_{i,k,t-3} < 85\right]$	0.003	0.004	0.003
	(0.011)	(0.011)	(0.009)
$MP_t \cdot \mathbf{1}\left[85 \geq CU_{i,k,t-3} < 100\right]$	0.004	0.005	0.005
	(0.004)	(0.006)	(0.006)
$MP_t \cdot \mathbf{1}\left[C_{i,k,t-3} = 1\right]$	0.011***	0.012**	0.009*
	(0.004)	(0.005)	(0.005)
Number of observations	141,013	141,013	141,013
Number of firms	1,174	1,174	1,174
R^2	0.181	0.279	0.365

This table reports estimation results for a version of equation (2) that separates firms into four groups: capacity-constrained firms ($C_{i,k,t-3}$, defined as in section 2.3) and unconstrained firms whose capacity-utilization levels ($CU_{i,k,t-3}$) fall in the intervals [0,70), [70,85), and [85,100), respectively. The omitted base category is unconstrained firms with capacity-utilization levels between zero and 70 percent. Standard errors are double-clustered by firm and time in all regressions. All estimations include time fixed effects. *, **, and *** denote statistical significance at the ten, five, and one percent levels, respectively.

3.3 The role of competitors' capacity constraints

Our final empirical exercise is to test whether the role of a firm's capacity constraints in the price response to monetary policy shocks depends on the constraints of its competitors. To begin with, panel (a) of Figure 7 plots the relative price responses of constrained and unconstrained firms that we obtain when estimating equation (2) separately for firms operating in industries with high and low shares of constrained firms, respectively. The difference in the price response between constrained and unconstrained firms is close to zero and statistically insignificant in industries with low shares of constrained firms (dashed red line), but positive and statistically significant in industries with high shares of constrained firms (solid blue line). Hence, firms' capacity constraints only matter for the sensitivity of their prices to monetary policy shocks when they operate in industries with many constrained firms. The magnitude of the relative price response in highly constrained industries is substantial: the largest difference in the price responses is nearly two percentage points, which is very large compared to the maximum un-

Figure 7: The role of competitors' capacity constraints



Panel (a) plots the relative price responses of constrained and unconstrained firms that we obtain when estimating equation (2) separately for firms operating in industries with high and low shares of constrained firms, respectively. Panel (b) plots the price responses to monetary policy shocks of constrained firms in unconstrained industries (dotted green line), unconstrained firms in constrained industries (dashed red line), and constrained firms in constrained industries (solid blue line), all relative to the response of unconstrained firms in unconstrained industries. The relative responses correspond to the following coefficient estimates obtained from equation (3): β^h (constrained firm), $\overline{\beta}^h$ (constrained industry), and $\beta^h + \overline{\beta}^h + \zeta^h$ (constrained firm and industry). The shaded areas are 90 percent confidence intervals, computed on the basis of standard errors double-clustered by firm and time.

conditional price response of 1.2 percent

Panel (b) of Figure 7 reports the relative price responses across four groups of firms, obtained from the estimation of the triple-differenced specification in equation (3). The four groups are: unconstrained firms in unconstrained industries, constrained firms in unconstrained industries, unconstrained firms in constrained industries, and constrained firms in constrained industries. The first of these is the omitted base group; hence, the responses plotted in the figure are the price responses to monetary policy shocks in the respective groups relative to the response in the base group. The results show that neither constrained firms in unconstrained industries (dotted green line) nor unconstrained firms in constrained industries (dashed red line) differ significantly from unconstrained firms in unconstrained industries in terms of price sensitivity to monetary policy shocks. The prices of products sold by constrained firms in constrained industries, on the other hand, respond significantly more to monetary shocks than those of other firms, with a peak difference in the price response of nearly three percentage points.

Taken together, the results reported in Figure 7 demonstrate that firms' capacity constraints do shape how their prices respond to monetary policy shocks, but only when they operate in industries where many other firms are also constrained. Firm- and industry-level capacity con-

straints thus interact to determine how sensitive product prices are to monetary policy shocks.

4 Model

To rationalize our empirical findings, we present a model that incorporates capacity constraints into a multi-industry New Keynesian framework with sticky prices and wages. Capacity constraints are modeled as restrictions on the amount of output firms are able to produce, and are potentially varying across firms. In contrast to the previous macroeconomic literature studying capacity constraints (see, e.g., Alvarez-Lois, 2006; Boehm and Pandalai-Nayar, 2022; Comin, Johnson and Jones, 2024), we assume that intermediate inputs are aggregated according to a Kimball (1995) aggregator. This allows for non-constant demand elasticities, and hence gives rise to strategic complementarities in firms' price setting decisions. As will be shown, this feature of the model will be crucial for matching our empirical results. The following sections describe the main features of the model, while section B1 in the appendix provides all model details.

4.1 Households and wage setting

Households choose consumption and savings, supply labor, and set nominal wages in staggered Calvo (1983) contracts following Erceg, Henderson and Levin (2000). Specifically, households supply differentiated labor services which are combined into a composite service by a competitive labor union. Each period, only a fraction $1-\upsilon$ of randomly selected households are allowed to renegotiate their nominal wages. Households have preferences which are additively separable in labor supply and consumption, with the latter defined by an aggregate over the industry consumption goods $\{c_{st}\}_{s\in[0,1]}$

$$c_t = \left(\int_0^1 c_{st}^{\frac{\eta-1}{\eta}} ds\right)^{\frac{\eta}{\eta-1}}$$

Expenditure minimization gives the industry demand curves $c_{st} = (\tilde{p}_{st})^{-\eta} c_t$, where $\tilde{p}_{st} := p_{st}/p_t$ denotes the price of industry s relative to the aggregate price index p_t which is pinned down by

$$1 = \left(\int_0^1 (\tilde{p}_{st})^{1-\eta} ds\right)^{\frac{1}{1-\eta}}$$

Optimal household behavior is characterized by the Euler equation, a transversality condition, and the reset wage w_t^* chosen whenever the household is allowed to renegotiate its wage.

4.2 Final goods firms

In each industry, a competitive aggregating firm uses a unit continuum of varieties l as inputs to produce the industry composite good y_{st} according to the Kimball (1995) aggregator

$$\int_0^1 \Upsilon\left(\tilde{y}_{lst}\right) dl = 1$$

where $\tilde{y}_{lst} := y_{lst}/y_{st}$ denotes the demand of variety l relative to the total industry output. We use the commonly adopted functional form from Dotsey and King (2005), which is given by[12]

$$\Upsilon\left(\tilde{y}_{lst}\right) = \frac{\theta}{\theta(1-\varepsilon)-1}\left[\left((1-\varepsilon)\tilde{y}_{lst}+\varepsilon\right)^{1-\frac{1}{\theta(1-\varepsilon)}}-1\right]+1$$

In the above expression, $\theta > 0$ denotes the average demand elasticity, whereas $\varepsilon \geq 0$ governs the "superelasticity" of demand, i.e. how the demand elasticity varies with relative demand $\tilde{y}_{lst}$.[13]

4.3 Intermediate goods firms

Intermediate goods are produced using labor h_{lst} according to $y_{lst} = h_{lst}$, subject to a capacity constraint. Following Comin, Johnson and Jones (2024), we assume that this capacity constraint takes the form of an exogenously imposed upper bound on production q_{lst} such that $y_{lst} \leq q_{lst}$. This means that capacity constitutes a "hard" constraint, i.e. firms can never raise production above their available capacity.[14] We are fundamentally interested in studying the pass-through from monetary policy to prices taking capacity constraints as given, rather than providing a microfoundation for how capacity evolves endogenously, and this choice is a tractable way of capturing that some firms are constrained and others are not. Firms make their price setting decisions with knowledge of whether their capacity constraint binds, and are assumed to always satisfy demand.[15] Nominal price changes are subject to the Rotemberg (1982) adjustment cost

$$\mathcal{C}_{lst} = \frac{\gamma_p}{2}\left(\pi_{lst}-1\right)^2 \tilde{p}_{st} y_{st}$$

[12] Another commonly adopted functional form is the one proposed by Klenow and Willis (2016), which is equivalent to our chosen aggregator up to a first-order approximation.

[13] In the same way as in Li, Lian, Ma and Martell (2025), we slightly rewrite the Dotsey and King (2005) specification to facilitate parameter interpretation.

[14] In constrast, a "soft" constraint could be circumvented by e.g. incurring higher costs.

[15] Alternatively, we could assume that firms ration their output, meaning that constrained firms set prices such that the quantity demanded is strictly larger than the quantity produced. Although difficult to test directly in the data, the broader implication of rationing would be smaller price differences between constrained and unconstrained firms. Since our empirical results reveal significant differences, we view rationing as unlikely to be widespread.

where γ_p governs the degree of price stickiness, and $\pi_{lst} := p_{lst}/p_{lst-1}$ denotes the inflation rate of variety l in industry s. Note that the model features a Calvo (1983) friction for wage setting, but a Rotemberg (1982) friction for price setting. The latter choice is to ensure that firms are always able to satisfy demand, which enables aggregation across individual firm decisions. Firms maximize profits subject to demand, the capacity constraint, and the price adjustment cost. The necessary first-order conditions of the optimization problem yield the price setting equation

$$\begin{aligned}\tilde{p}_{lst} = \mu_{lst}(\tilde{y})\frac{(mc_{lst}+\lambda_{lst})}{\tilde{p}_{st}} \\ + \frac{\gamma_p}{\zeta_{lst}(\tilde{y})-1}\mathbb{E}_t\left[m_{t,t+1}\left(\pi_{lst+1}-1\right)\pi_{lst+1}\frac{y_{st+1}}{y_{lst}}\frac{\tilde{p}_{st+1}}{\tilde{p}_{st}} - \left(\pi_{lst}-1\right)\frac{\pi_{lst}}{\tilde{y}_{lst}}\right]\end{aligned} \tag{6}$$

where $\tilde{p}_{lst} := p_{lst}/p_{st}$ denotes the price of variety l relative to its sectoral price index. As can be seen from equation (6), firms' optimal price setting decisions can be decomposed into three separate parts. The first part comprises the product between a term featuring the demand elasticity, $\mu_{lst}(\tilde{y}) := \zeta_{lst}(\tilde{y})/(\zeta_{lst}(\tilde{y})-1)$, and the real marginal cost $mc_{lst} = w_t$, where w_t denotes the real aggregate wage rate. In the absence of capacity constraints and nominal rigidities, this would be the only part present and $\mu_{lst}(\tilde{y})$ would represent the firm's markup. Importantly, due to the Kimball (1995) aggregator, note that demand elasticities are varying and given by

$$\zeta_{lst}(\tilde{y}) := -\frac{\partial \ln \tilde{y}_{lst}}{\partial \ln \tilde{p}_{lst}} = \theta\left(1+\varepsilon\frac{1-\tilde{y}_{lst}}{\tilde{y}_{lst}}\right)$$

When $\varepsilon > 0$, the elasticity is decreasing, and the markup is increasing, in the relative demand $\tilde{y}_{lst}$. This conversely implies that the markup is decreasing in the firm's relative price, hence capturing strategic complementarities in price setting. When $\varepsilon = 0$, however, the demand elasticity reduces to the constant $\zeta_{lst}(\tilde{y}) = \theta$. The second part of equation (6) comprises λ_{lst}, which is the Lagrange multiplier on the capacity constraint in the firm's maximization problem. Note that capacity constrained firms will have will have $\lambda_{lst} > 0$, which directly translates into a higher markup. The intuition behind this observation is that constrained firms need to raise their prices (and, hence, markups) to accommodate demand, since they are not able to adjust production. In contrast, unconstrained firms will have $\lambda_{lst} = 0$. The interaction between λ_{lst} and the non-constant $\mu_{lst}(\tilde{y})$ present in this part of the price setting equation for constrained firms will be crucial for generating model predictions that match our empirical results. Finally, the third part of the equation arises from the nominal rigidities (and, thus, vanishes if $\gamma_p = 0$), and involves a forward-looking component including the stochastic discount factor $m_{t,t+1}$, which is pinned down by optimal household behavior.

4.4 Monetary authority

The central bank sets the nominal interest rate according to the Taylor rule

$$R_t = (1 + R_{t-1})^{\phi_R} \left((1 + \overline{R})(\pi_t)^{\phi_\pi} \right)^{1-\phi_R} \exp(\mathcal{M}_t) - 1$$

where the exogenous shock component $\mathcal{M}_t$ evolves according to an AR(1) process with mean zero, persistence ρ_R, and volatility σ_R. Furthermore, $\overline{R} = 1/\beta - 1$ denotes the steady state level of the nominal interest rate. Section B2 in the appendix presents results when additionally including the output gap in the above Taylor rule.

4.5 Firm heterogeneity and aggregation

In order to keep the model tractable, we focus on the case with a finite number S of industries, and a finite number N_s of distinct firm types within each industry, denoted by k, which potentially differ in their capacity levels q_{kst}. Since this is the only source of heterogeneity in the model, firm choices will be symmetric within each (k, s) combination. We denote the mass of firms of type k in industry s by Ω_{ks}, and the mass of each industry by ω_s, with $\sum_k \Omega_{ks} = 1$ and $\sum_s \omega_s = 1$. Furthermore, we assume that capacity is fixed over time and determined by the parameter $q_{kst} = \xi_{ks}$.

4.6 Calibration

We calibrate the model to quarterly frequency. The baseline parameter values are presented in table 3. Throughout, we assume two industries ($S = 2$), and two firm types within each industry ($N_s = 2, \forall s$) with varying levels of capacity $\xi_{1s} < \xi_{2s}$ such that type 1 is constrained and type 2 is unconstrained in steady state. Capacity levels are furthermore assumed to be equal across industries, i.e. $\xi_{ks} = \xi_k, \forall s$, for a given k. We calibrate ξ_1 to target an aggregate (sales-weighted) markup equal to 1.6 in steady state, which is in line with empirical markup estimates (see, e.g., De Loecker, Eeckhout and Unger, 2020; Döpper, MacKay, Miller and Stiebale, 2025). We choose an average demand elasticity equal to $\theta = 6$, which is a standard value for New Keynesian models. Then we set ε to obtain an average steady state markup elasticity equal to -0.99, which corresponds to the mean empirical estimate in Beck and Lein (2020). In our model, the markup elasticity is defined by $\partial \ln \mu_{lst}(\tilde{y}) / \partial \ln \tilde{p}_{lst} = -\theta\varepsilon/(\theta - 1)$, thus we get $\varepsilon = 0.825$. Note that this value is considerably lower than what is typically used in the macroeconomic literature, which means that our calibration assigns a weaker role to strategic

Table 3: Baseline calibration

Parameter	Description	Value
β	Time discount	0.99
χ	Inverse of Frisch elasticity	0.2
θ	Elasticity of sub., varieties	6
ε	Governs superelasticity	0.825
γ_p	Price adjustment cost	9.9
υ	Wage adjustment probability	0.75
θ_w	Elasticity of sub., labor services	21
ϕ_R	Monetary policy inertia	0.7
ϕ_π	Taylor rule inflation coefficient	1.5
ρ_R	Persistence of monetary policy shock	0.5
σ_R	Volatility of monetary policy shock	0.009
ψ	Utility weight on labor disutility	1
ξ_1	Capacity firm type 1	0.297
ξ_2	Capacity firm type 2	10
σ	CRRA parameter	1
η	Elasticity of sub., industries	0.5
Ω_{11}	Share of constrained firms	0.79
Ω_{12}	Share of constrained firms	0.27
ω_1	Industry mass	0.25
N_s	Firm types	2
S	Number of industries	2

complementarities.[16] The across- and within-industry shares ω_1 and Ω_{1s} are calibrated based on the distribution of constrained firms observed in our data. In particular, as in the empirical analysis, we separate between an industry with a high and a low share of constrained firms. The mass of the former industry, ω_1, is set to match the (sales-weighted) share of industries with more than 60 percent constrained firms in our data, i.e. the same cutoff value as used in the empirical analysis. This yields $\omega_1 = 0.25$. Moreover, the average shares of constrained firms within high and low share industries in our data equal 79 percent and 27 percent, respectively,

[16]For instance, Smets and Wouters (2007) calibrate this parameter to $\varepsilon = 10$, while Harding, Lindé and Trabandt (2022) obtain a posterior mode value of $\varepsilon = 16.37$ in an estimated DSGE model.

and hence we set $\Omega_{11} = 0.79$ and $\Omega_{12} = 0.27$. Following Comin, Johnson and Jones (2024), we choose an elasticity of substitution across industries equal to $\eta = 0.5$, which implies that the industry composite goods are complements. In section B2 in the appendix, we present results when instead assuming $\eta > 1$ (substitutes) and $\eta = 1$ (Cobb-Douglas), respectively. The price adjustment cost γ_p is set to be first-order equivalent to a Calvo (1983) setup with an average price duration of two quarters, which roughly corresponds to the value reported for producer prices by Nakamura and Steinsson (2008).[17] In line with empirical evidence, we set υ such that wages are more sticky than prices. Specifically, we follow Erceg, Henderson and Levin (2000) and choose $\upsilon = 0.75$, which implies an average wage duration of four quarters; moreover, we set the elasticity of substitution across labor services to $\theta_w = 21$ following Comin, Johnson and Jones (2024). The volatility of the monetary policy shock σ_R is scaled to generate a cumulative aggregate peak increase in prices which is close to our empirical estimates. The remaining parameters governing household preferences and the Taylor rule are chosen to typical values used in the New Keynesian literature. We solve the model using Dynare's OccBin routine which implements the piecewise linear solution method proposed by Guerrieri and Iacoviello (2015).

5 Model Results

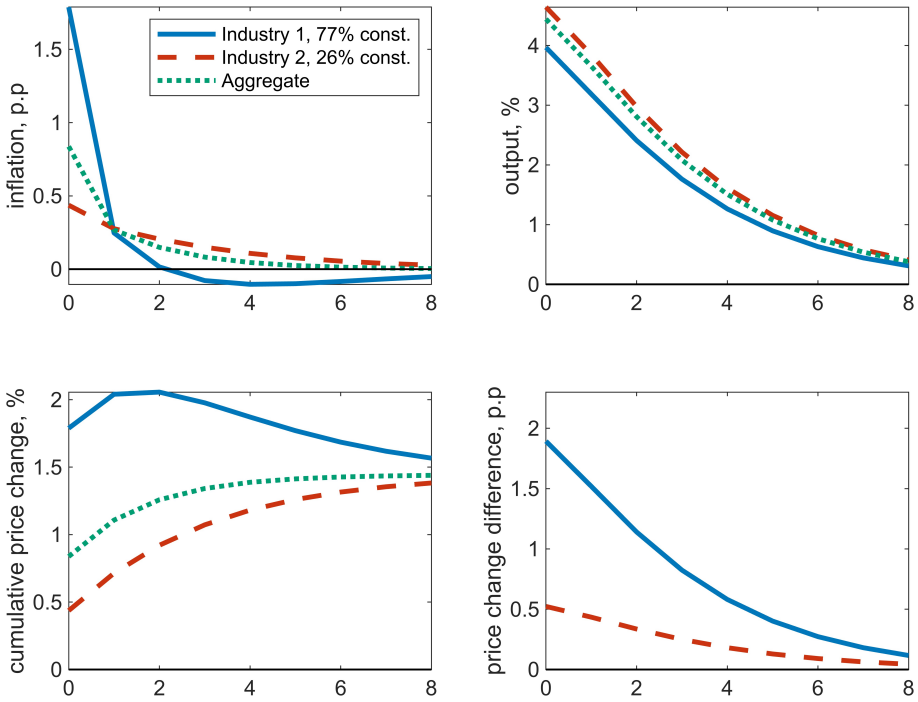
5.1 Baseline impulse responses

Figure 8 displays the model impulse responses to an expansionary monetary policy shock with our baseline calibration. The solid blue and dashed red lines refer to the industry-level responses of industries with a high and low share of capacity constrained firms, respectively, while the dotted green lines refer to aggregate responses. As can be seen in the two upper panels of the figure, the industry with a high share of constrained firms displays a weaker output response and a considerably stronger inflation response than the industry with a low share. The reason for this is straightforward — constrained firms need to raise prices more since they are unable to accommodate the higher demand by increasing output. This can further be seen in the lower left panel of the figure, which shows that the cumulative price change of the industry with more constrained firms remains elevated up to two years after the shock hits.

Next, the lower right panel displays the absolute difference in the cumulative price change between constrained and unconstrained firms in each of the industries, i.e. the model equivalent

[17] In particular, we set γ_p such that the slopes of the log-linearized New Keynesian Phillips curve in a version of our model with homogeneous (unconstrained) firms are equal with Rotemberg (1982) and Calvo (1983) pricing. This is achieved when $\gamma_p = (\theta - 1)c/(1 - c)(1 - \beta c)$, where $c = 1/2$ refers to the Calvo parameter, and gives $\gamma_p = 9.9$.

Figure 8: Baseline model impulse responses

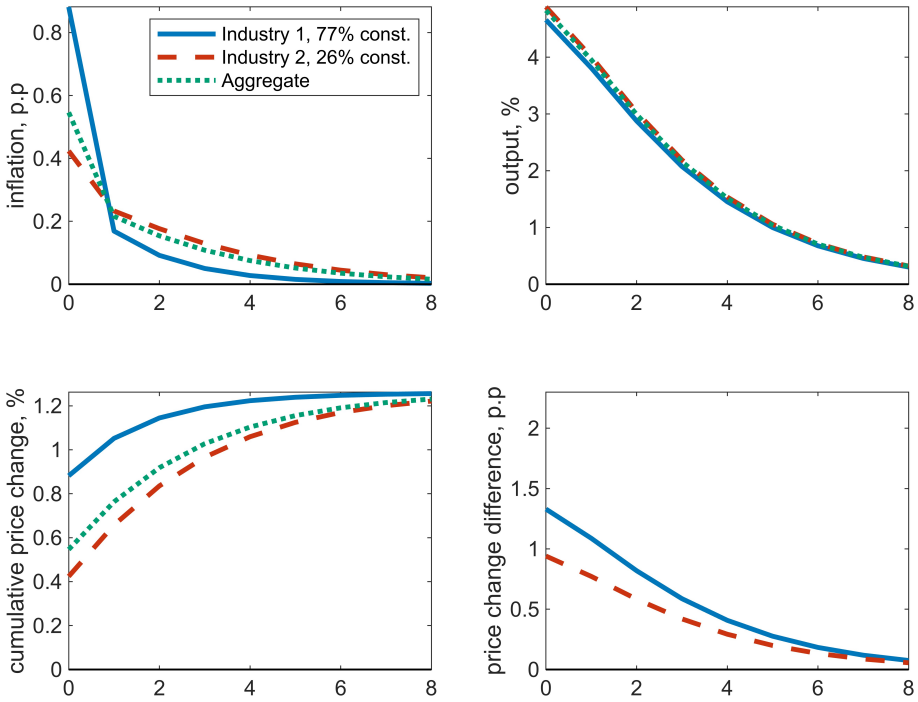


This figure shows the effect of an expansionary monetary policy shock on output and prices in our baseline model. The x-axes of the plots represent quarters since the monetary policy shock hit. Solid blue and dashed red lines refer to industry-level responses, while the dotted green lines refer to aggregate responses.

of the left panel of figure 7. In the industry with a high share of constrained firms, the difference is large and persistent, while in the industry with a low share it is close to zero throughout the forecast horizon, in line with the empirical results in section 3.3. Note that the magnitudes of the model responses align closely with their empirical counterparts. In the industry with a high share, the initial difference equals almost 2 percentage points, while in the industry with a low share it is 0.5 percentage points. For comparison, figure 9 displays the equivalent model responses when removing strategic complementarities by setting $\varepsilon = 0$. With this calibration, the industry composition of constrained firms matters considerably less for the difference in price responses between constrained and unconstrained firms; now both industries display clearly positive and highly similar differences, respectively equal to 1.33 and 0.94 percentage points. Hence, accounting for strategic complementarities is crucial to match our empirical findings.

To better understand this result, consider the interaction term between $\zeta_{kst}(\tilde{y})/(\zeta_{kst}(\tilde{y}) - 1)$ and λ_{kst} in the price setting equation (6). When the share of constrained firms within an industry

Figure 9: Model impulse responses without strategic complementarities



This figure shows the effect of an expansionary monetary policy shock on output and prices in our baseline model adjusted to not feature strategic complementarities in price setting ($\varepsilon = 0$). The x-axes of the plots represent quarters since the monetary policy shock hit. Solid blue and dashed red lines refer to industry-level responses, while the dotted green lines refer to aggregate responses.

Ω_{1s} increases, their relative demand $\tilde{y}_{1st}$ mechanically increases, which in turn implies that their demand elasticity $\zeta_{1st}(\tilde{y})$ decreases. Consequently, any given change in λ_{1st}, for instance induced by the monetary policy shock, will translate into a larger price change. This means that the importance of capacity constraints for price setting directly depends on the industry composition of constrained firms through strategic complementarities. In other words, our model features an interaction between capacity constraints and strategic complementarities which generates larger price differences between constrained and unconstrained firms in industries with a higher share of constrained firms. To provide some intuition behind this mechanism, one can think of constrained firms in industries with a low share of such firms as being reluctant to raise prices following the shock because this will hurt their competitiveness. When the constrained firms are in majority, however, they know that most of the firms in the industry will raise prices and hence are less concerned about what the unconstrained firms are doing. Eliminating the role of strategic complementarities of course makes this interaction inoperative, implying that the

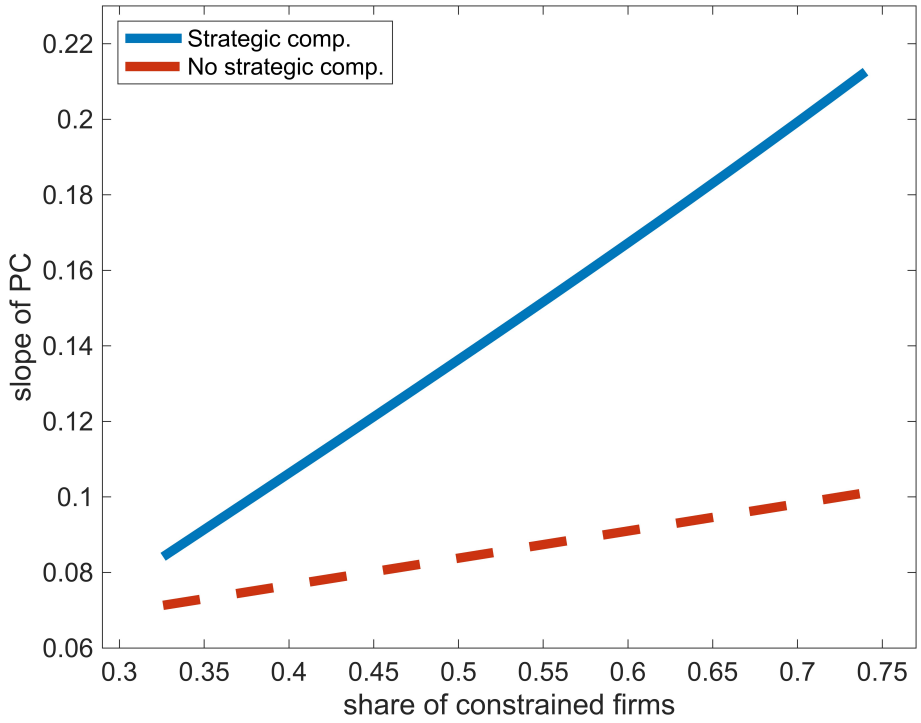
industry composition will matter considerably less for the difference in price responses between constrained and unconstrained firms.

5.2 Implications for the aggregate Phillips curve

In the following section, we explore the implications of capacity constraints and strategic complementarities in price setting for the slope of the aggregate Phillips curve in our model. To begin with, figure 10 plots the implied slopes of the Phillips curve when varying the mass of industries with a high share of constrained firms, ω_1, along a linearly spaced grid between 10 percent and 90 percent, while holding Ω_{11} and Ω_{12} fixed at their baseline values. This implies varying the overall share of constrained firms in the economy between 32 and 75 percent, but keeping the within industry composition fixed. For each point on the grid, we feed a sequence of $10,000$ monetary policy shocks into the model, derive output gap and inflation responses, and compute the implied linear slope via a standard OLS fit. The blue line represents our baseline model, i.e. the one that includes strategic complementarities in price setting, while the red line represents the model excluding it. In both cases, the slope of the Phillips curve increases linearly in the share of constrained firms in the economy. This is because increasing ω_1 simply shifts weight towards the industry with a stronger price response. Importantly, the increase in slope is notably larger in the model that includes strategic complementarities, which is due to the mechanism that makes constrained firms in industries with a high share of constrained firms react stronger to monetary policy shocks, as discussed in the previous section.

An important implication of our previous results, however, is that not only the average share of capacity constrained firms, but also the distribution of constrained firms across industries, could matter for the transmission of monetary policy to prices. In what follows, we explore this in detail by computing model implied slopes of the aggregate Phillips curve when adjusting this distribution. This is done by varying the distance between the share of constrained firms in both industries, Ω_{11} and Ω_{12}, such that the average share of constrained firms $\overline{C} = \omega_1\Omega_{11} + (1-\omega_1)\Omega_{12}$ remains fixed at its baseline level. For each combination of Ω_{11} and Ω_{12}, we feed a sequence of $10,000$ monetary policy shocks into the model and compute the implied (linear) slope in the same way as before. The results from this exercise are shown in figure 11, both when including and excluding strategic complementarities in price setting. In the leftmost part of the figure, the shares of constrained firms are equal at $\overline{C} = 40$ percent across both industries, while moving to the right corresponds to an increasing difference between Ω_{11} and Ω_{12}. Note that all slopes are plotted relative to the slope implied by the equal distribution.

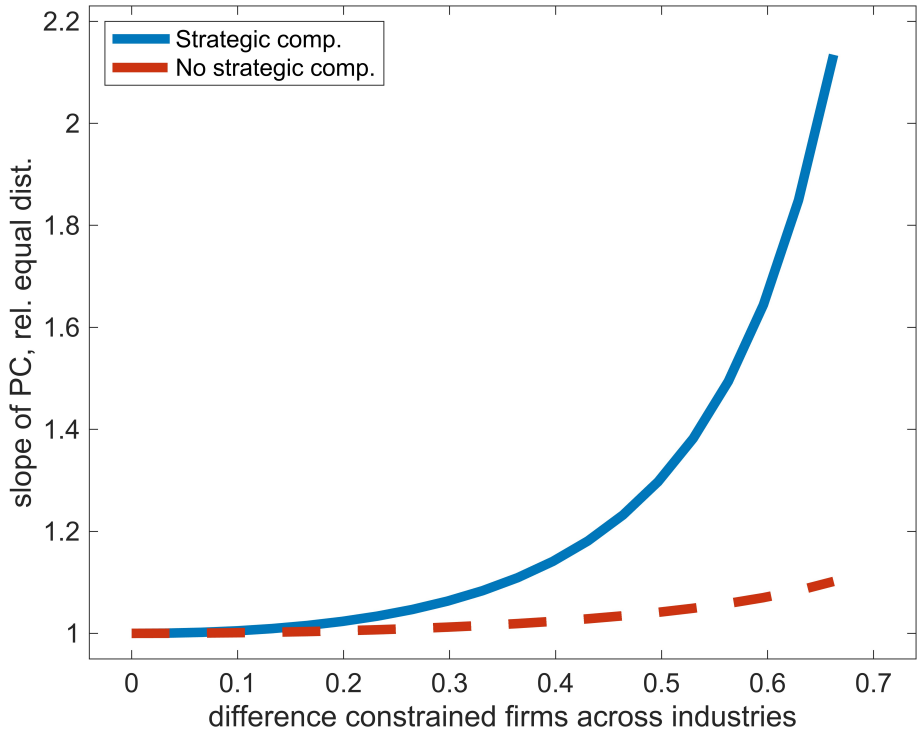
Figure 10: Share of constrained firms and the Phillips curve



This figure shows the implied (linear) slope of the Phillips curve when varying the mass of industries with a high share of constrained firms, ω_1, in our model. The blue and red lines respectively refer to the slopes in the models with and without strategic complementarities in price setting. The slope is computed as a linear (OLS) fit of output and inflation responses to a sequence of $10,000$ monetary policy shocks.

In the model with strategic complementarities (blue line), the distribution of constrained firms across industries significantly affects the slope of the Phillips curve. In particular, raising the spread of the share of constrained firms from 0 to 0.7 implies more than doubling the slope. The reason is that when most of the constrained firms are concentrated in one industry, the interaction between capacity constraints and strategic complementarities implies an accelerating price response of constrained firms in this industry, which sharply increases the slope. In contrast, the model without strategic complementarities (red line) features a much less prominent role for the distribution of constrained firms across industries. Specifically, when going from 0 to 0.7 in spread between the industries, the slope increases by less than 10 percent. In sum, these results suggest that the pass-through of monetary policy to prices depends on how capacity constraints are distributed across industries, even when holding the average share of constrained firms in the economy fixed.

Figure 11: Distribution of constrained firms and the Phillips curve



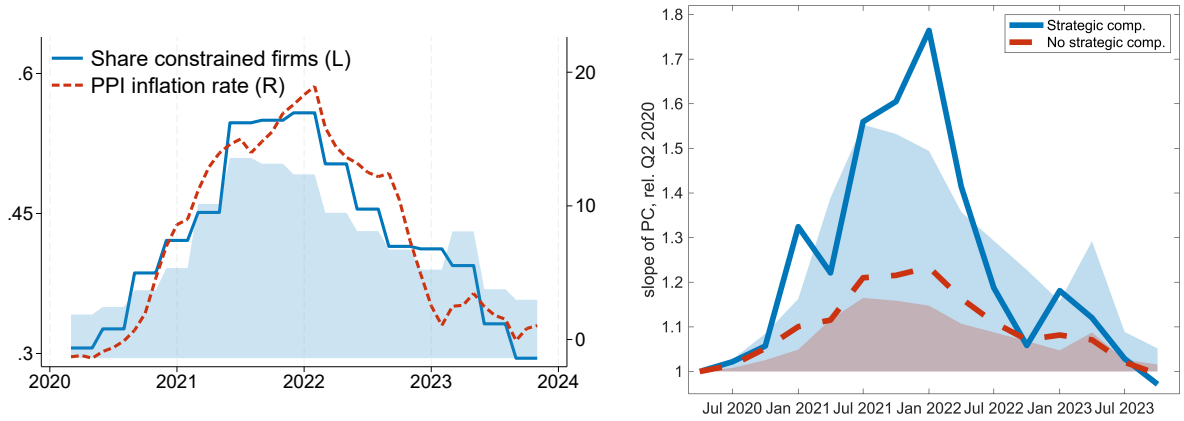
This figure shows the relative slope of the Phillips curve when varying the share of constrained firms in both industries Ω_{11} and Ω_{12} such that the average share of constrained firms in the economy $\overline{C} = \omega_1\Omega_{11} + (1-\omega_1)\Omega_{12}$ remains fixed at its baseline level. The slopes are plotted relative to its value in the calibration with an equal share of constrained firms across both industries. The blue and red lines respectively refer to the models with and without strategic complementarities in price setting. The slope is computed as a linear (OLS) fit of output and inflation responses to a sequence of $10,000$ monetary policy shocks.

5.3 The recent inflation surge

During the recent high inflation period, both the average share and the within industry composition of constrained firms changed.

During the recent high inflation period, the average share of constrained in the Swedish industrial sector increased. An even more salient feature of this period, however, was that the share of industries with a high share of constrained firms (according to the cutoff used in the empirical analysis) rose dramatically. This is shown in the left panel of figure 12. While the share of constrained firms increased from 30 percent to 55 percent between $2020Q2$ and the peak of inflation in Sweden (end of 2021/beginning of 2022), the share of highly constrained industries increased from 15 percent to 45 percent, i.e. a threefold increase. In what follows, we explore the effect of this shift on the slope of the Phillips curve.

Figure 12: Capacity constraints and the Phillips curve during the inflation surge



(a) Capacity constraints in the data

(b) Model implied Phillips curve

The left panel of this figure shows for the Swedish domestic industrial sector (SPIN sections B and C) during the high inflation period $2020Q2 - 2023Q4$: (i) the aggregate year-on-year PPI inflation rate (blue solid line), (ii) the (sales-weighted) share of capacity constrained firms (red dashed line), and (iii) the (sales-weighted) share of industries with a high share of constrained firms (cutoff 60% as in the empirical analysis, green dotted line). The right panel of this figure shows the relative slope of the implied Phillips curve when varying the share of industries with a high share of constrained firms, ω_1, in our model, according to the observed share during the high inflation period. The slopes are plotted relative to the value in the first period $2020Q2$. The blue and red dots respectively refer to the models with and without strategic complementarities in price setting. The slope is computed as a linear (OLS) fit of output and inflation responses to a sequence of $10,000$ monetary policy shocks.

For each quarter between $2020Q2$ and $2023Q4$, we set ω_1, the mass of the industry with a high share of constrained firms in our model, according to the value observed in our micro data (green dotted line of figure 12), and compute the implied slope as before. The results are presented in the right panel of figure 12. With our baseline calibration that includes strategic complementarities, the slope of the Phillips curve increases by 50 percent at its peak relative to the value prior to the inflation surge. This happens because weight is shifted towards the industry whose prices respond stronger to the monetary policy shock, which yields an elevated aggregate inflation response. When strategic complementarities are removed, the difference in price responses between constrained and unconstrained firms is smaller, which also means that inflation responses across the two industries are more similar, implying a considerably smaller increase (around 15 percent) in the slope of the Phillips curve. Thus, in line with the model presented in Comin, Johnson and Jones (2024), capacity constraints in combination with positive demand shocks can generate an acceleration of inflation in our model. Relative to their analysis, however, we show that jointly accounting for capacity constraints and strategic complementar-

ities further elevates this acceleration, which could help explain the rapid shift from a low- to high inflation environment observed during the recent episode.

6 Conclusion

Our analysis suggests that capacity constraints constitute an important driver of price setting behavior and inflation dynamics. Using granular data on prices and capacity constraints for a representative sample of firms within the Swedish industrial sector, we find that not only firms' own constraints, but also the constraints of their closest competitors, determine their price responses to an exogenous monetary policy shock. A multi-industry New Keynesian model with heterogeneous firms, capacity constraints, and strategic complementarities in price setting via a Kimball (1995) aggregator can reconcile these empirical findings. Importantly, when instead considering the standard CES aggregator, the role of competitors' capacity constraints is considerably reduced. This points towards strategic complementarities as an important aspect of firms' pricing decisions, in line with recent empirical evidence (Albagli et al., 2025). We show that the model implied slope of the aggregate Phillips curve varies both with the average share of constrained firms in the economy, and with the distribution of constrained firms across industries holding the average share fixed. Calibrating the model to match the observed average level and distribution of constraints observed in Sweden during the recent high inflation episode, we find that the Phillips curve steepened by roughly 50 percent over this period. Thus, our results suggest that the distribution of capacity constrained firms across industries is a relevant metric for monetary policymakers to pay attention to.

Consequently, it could be relevant for policymakers to pay attention to such measures in conjunction with e.g. the average level of capacity utilization in the economy.

References

Albagli, Elias, Francesco Grigoli, Emiliano Luttini, Dagoberto Quevedo, and Rojas Marco. 2025. "Beyond Costs: The Dominant Role of Strategic Complementarities in Pricing." *Working Paper No. 1051, Central Bank of Chile*.

Alvarez-Lois, Pedro. 2006. "Endogenous Capacity Utilization and Macroeconomic Persistence." *Journal of Monetary Economics*, 53(8): 2213–2237.

Amberg, Niklas, Thomas Jansson, Mathias Klein, and Anna Rogantini Picco. 2022. "Five Facts about the Distributional Income Effects of Monetary Policy Shocks." *American Economic Review: Insights*, 4(3): 289–304.

Balleer, Almut, and Marvin Noeller. 2023. "Monetary Policy in the Presence of Supply Sonstraints: Evidence from German Firm-Level Data." *CESifo Working Paper*.

Baqaee, David R., Emmanuel Farhi, and Kunal Sangani. 2024. "The Supply-Side Effects of Monetary Policy." *Journal of Political Economy*, 132(4): 1065–1112.

Bauer, Michael D., and Eric T. Swanson. 2023. "A Reassessment of Monetary Policy Surprises and High-Frequency Identification." *NBER Macroeconomics Annual*, 37(1): 87–155.

Beck, Günter W., and Sarah M. Lein. 2020. "Price Elasticities and Demand-Side Real Rigidities in Micro Data and in Macro Models." *Journal of Monetary Economics*, 115: 200–212.

Boehm, Christoph E., and Nitya Pandalai-Nayar. 2022. "Convex Supply Curves." *American Economic Review*, 112: 3941–69.

Calvo, Guillermo A. 1983. "Staggered Prices in a Utility-Maximizing Framework." *Journal of Monetary Economics*, 12(3): 383–398.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy*, 113(1): 1–45.

Coglianese, John M., Maria Olsson, and Christina Patterson. 2023. "Monetary Policy and the Labor Market: A Quasi-Experiment in Sweden." University of Chicago Becker Friedman Institute for Economics Working Paper No. 2023-123.

Comin, Diego A., Robert C. Johnson, and Callum J. Jones. 2024. "Supply Chain Constraints and Inflation." NBER Working Paper No. 31179.

D'Acunto, Francesco, Ryan Liu, Carolin Pflueger, and Michael Weber. 2018. "Flexible Prices and Leverage." *Journal of Financial Economics*, 129: 46–68.

De Loecker, Jan, Jan Eeckhout, and Gabriel Unger. 2020. "The Rise of Market Power and the Macroeconomic Implications." *The Quarterly Journal of Economics*, 135(2): 561–644.

Döpper, Hendrik, Alexander MacKay, Nathan H Miller, and Joel Stiebale. 2025. "Rising Markups and the Role of Consumer Preferences." *Journal of Political Economy*, 133(8): 2462–2505.

Dotsey, Michael, and Robert G. King. 2005. "Implications of State-Dependent Pricing for Dynamic Macroeconomic Models." *Journal of Monetary Economics*, 52(1): 213–242.

Erceg, Christopher J, Dale W Henderson, and Andrew T Levin. 2000. "Optimal Monetary Policy with Staggered Wage and Price Contracts." *Journal of Monetary Economics*, 46(2): 281–313.

Gertler, Mark, and Peter Karadi. 2015. "Monetary Policy Surprises, Credit Costs, and Economic Activity." *American Economic Journal: Macroeconomics*, 7(1): 44–76.

Gilchrist, Simon, Raphael Schoenle, Jae Sim, and Egon Zakrajšek. 2017. "Inflation Dynamics During the Financial Crisis." *American Economic Review*, 107(3): 785–823.

Guerrieri, Luca, and Matteo Iacoviello. 2015. "OccBin: A Toolkit for Solving Dynamic Models with Occasionally Binding Constraints Easily." *Journal of Monetary Economics*, 70: 22–38.

Hanson, Samuel G., and Jeremy C. Stein. 2015. "Monetary Policy and Long-Term Real Rates." *Journal of Financial Economics*, 115(3): 429–448.

Harding, Martín, Jesper Lindé, and Mathias Trabandt. 2022. "Resolving the Missing Deflation Puzzle." *Journal of Monetary Economics*, 126: 15–34.

Holm, Martin Blomhoff, Pascal Paul, and Andreas Tischbirek. 2021. "The Transmission of Monetary Policy under the Microscope." *Journal of Political Economy*, 129(10): 2861–2904.

Jarociński, Marek, and Peter Karadi. 2020. "Deconstructing Monetary Policy Surprises—The Role of Information Shocks." *American Economic Journal: Macroeconomics*, 12(2): 1–43.

Kimball, Miles S. 1995. "The Quantitative Analytics of the Basic Neomonetarist Model." *Journal of Money, Credit and Banking*, 27(4): 1241–1277.

Kim, Ryan. 2021. "The Effect of the Credit Crunch on Output Price Dynamics: The Corporate Inventory and Liquidity Management Channel." *The Quarterly Journal of Economics*, 136(1): 563–619.

Klenow, Peter J., and Jonathan L. Willis. 2016. "Real Rigidities and Nominal Price Changes." *Economica*, 83(331): 443–472.

Li, Huiyu, Chen Lian, Yueran Ma, and Emily Martell. 2025. "Borrowing Constraints, Markups, and Misallocation." NBER Working Paper No. 33960.

Nakamura, Emi, and Jón Steinsson. 2008. "Five Facts About Prices: A Reevaluation of Menu Cost Models." *The Quarterly Journal of Economics*, 123(4): 1415–1464.

Nakamura, Emi, and Jón Steinsson. 2018. "High-Frequency Identification of Monetary Non-Neutrality: The Information Effect." *The Quarterly Journal of Economics*, 133(3): 1283–1330.

Rodrigues, Diego, and Tim Willems. 2025. "Inventories Matter for the Transmission of Monetary Policy: Uncovering the Cost-of-Carry Channel." *Working paper*.

Romer, Christina D., and David H. Romer. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review*, 94: 1055–1084.

Rotemberg, Julio J. 1982. "Sticky Prices in the United States." *Journal of Political Economy*, 90(6): 1187–1211.

Smets, Frank, and Rafael Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review*, 97(3): 586–606.

Wang, Olivier, and Iván Werning. 2022. "Dynamic Oligopoly and Price Stickiness." *American Economic Review*, 112(8): 2815–2849.

Online Appendix for "Do Capacity Constraints Affect the Pass-Through of Monetary Policy to Prices?"

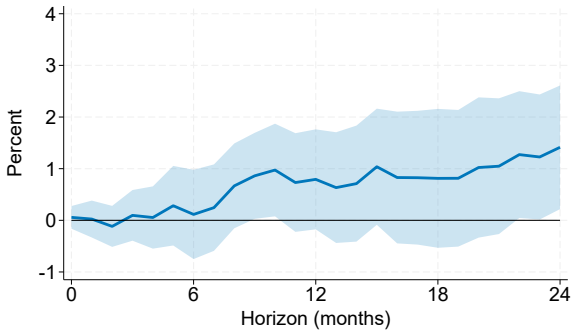
Edvin Ahlander, Niklas Amberg, and Mathias Klein

Appendix A. Additional Tables and Figures

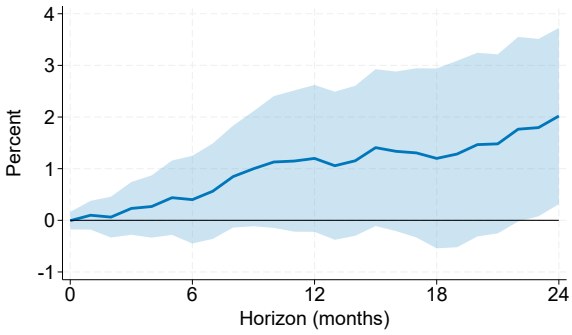
This appendix provides the additional tables and figures referred to in the main text of the paper. Figure A1 reports estimates of the average response of product prices to monetary policy shocks from weighted regressions and time-series regressions.

Figure A1: Comparing the micro-level and macro-level producer price responses

(a) Estimates from weighted regressions



(b) Estimates from time-series regressions



This figure shows the effect of a 25 basis points expansionary monetary policy shock on product prices. Panel (a) plots the estimates we obtain when weighing the observations in (2) with the official PPI weights. Panel (b) plots estimates from the time-series equivalent of (2)—that is, $\ln p_{t+h} - \ln p_{t-1} = \alpha + \beta^h \cdot MP_t + \psi^h \cdot \mathbf{X}_t + \varepsilon_t^h$, where p_t is the aggregate producer-price index for domestically produced goods in SPIN sectors B and C. The shaded areas are 90 percent confidence intervals, computed on the basis of standard errors double-clustered by firm and time.

Appendix B. Model Appendix

B1 Full model description

This section lays out all details concerning the model presented in section 4. The model features multiple industries, heterogeneous firms, capacity constraints, strategic complementarities in price setting via a Kimball (1995) aggregator, and nominal rigidities in the form of both sticky prices and wages, and comprises a household sector, a labor union, final and intermediate goods sectors, and a monetary authority.

B1.1 Labor unions

The wage setting procedure follows Erceg, Henderson and Levin (2000). There is a unit continuum of identical and monopolistically competitive households j who each supply a differentiated labor service h_{jt} at the nominal wage rate W_{jt}. A competitive labor union combines the labor services into the composite labor service h_t according to the CES aggregator

$$h_t = \left(\int_0^1 h_{jt}^{\frac{\theta_w - 1}{\theta_w}} dj \right)^{\frac{\theta_w}{\theta_w - 1}}$$

where θ_w denotes the elasticity of substitution across labor services. Note that this setup implicitly assumes that labor is perfectly mobile across industries. The labor union rents the composite labor service to firms at the aggregate nominal wage rate W_t. Thus, it solves the following profit maximization problem

$$\max_{h_{jt}} W_t \left(\int_0^1 h_{jt}^{\frac{\theta_w - 1}{\theta_w}} dj \right)^{\frac{\theta_w}{\theta_w - 1}} - \int_0^1 W_{jt} h_{jt} dj$$

The first order condition gives the demand function for the labor service of household j

$$h_{jt} = \left(\frac{w_{jt}}{w_t} \right)^{-\theta_w} h_t \tag{B1}$$

where $w_{jt} := W_{jt}/p_t$ and $w_t := W_t/p_t$ denote real wage rates, and p_t the aggregate price index to be defined later. Using the zero profit condition of the labor union, i.e. $w_t h_t = \int_0^1 w_{jt} h_{jt} dj$, we obtain the aggregate wage index

$$w_t = \left(\int_0^1 w_{jt}^{1-\theta_w} dj \right)^{\frac{1}{1-\theta_w}} \tag{B2}$$

B1.2 Households

The household problem is split up into three separate parts. First, households set their nominal wages W_{jt} in staggered Calvo (1983) contracts, in line with Erceg, Henderson and Levin (2000). Specifically, in every period, a constant fraction $1-\upsilon$ of randomly selected households is allowed to renegotiate their wages. Consequently, in a given period t in which a household is allowed to do so, the Lagrangian of the associated maximization problem is given by

$$\mathcal{L} = \mathbb{E}_t \sum_{s=0}^{\infty} (\upsilon\beta)^s \left[-\psi \frac{\left(\left(\frac{w_{jt}}{w_{t+s}} \frac{p_t}{p_{t+s}} \right)^{-\theta_w} h_{t+s} \right)^{1+\chi}}{1+\chi} + \lambda_{t+s}^w p_t w_{jt} \left(\frac{w_{jt}}{w_{t+s}} \frac{p_t}{p_{t+s}} \right)^{-\theta_w} h_{t+s} \right]$$

which combines the household preferences over labor supply (the complete utility function is specified below) with the labor demand equation (B1), while λ_t^w denotes the Lagrange multiplier. Solving for the optimal reset wage, denoted by w_t^*, from the first order condition gives

$$(w_t^*)^{1+\theta_w\chi} = \frac{\theta_w}{\theta_w - 1} \frac{H_{1,t}}{H_{2,t}} \tag{B3}$$

with the auxiliary variables $H_{1,t}$ and $H_{2,t}$ being pinned down by the recursions

$$\begin{aligned} H_{1,t} &= \psi w_t^{\theta_w(1+\chi)} h_t^{1+\chi} + \upsilon\beta\mathbb{E}_t(\pi_{t+1})^{\theta_w(1+\chi)} H_{1,t+1} \\ H_{2,t} &= c_t^{-\sigma} w_t^{\theta_w} h_t + \upsilon\beta\mathbb{E}_t(\pi_{t+1})^{\theta_w - 1} H_{2,t+1} \end{aligned}$$

where $c_t^{-\sigma}$ denotes the marginal utility of consumption (derived below) and $\pi_t := p_t/p_{t-1}$ the aggregate inflation rate. Since the households who are allowed to renegotiate their wages are randomly chosen, we can moreover rewrite the expression for the aggregate wage index (B2) as

$$w_t^{1-\theta_w} = (1-\upsilon)(w_t^*)^{1-\theta_w} + \upsilon(\pi_t)^{\theta_w - 1} w_{t-1}^{1-\theta_w} \tag{B4}$$

Second, there is a unit continuum of industries s with associated industry composite goods c_{st}, which households have preferences over according to

$$c_t = \left(\int_0^1 c_{st}^{\frac{\eta-1}{\eta}} ds \right)^{\frac{\eta}{\eta-1}}$$

In other words, households need to decide how to allocate their total consumption expenditure across the different industry composite goods. Expenditure minimization yields the solution, i.e.

the industry demand curves

$$c_{st} = (\tilde{p}_{st})^{-\eta} c_t \tag{B5}$$

where $\tilde{p}_{st} := p_{st}/p_t$ denotes the relative price of industry s's composite good. Hence, we obtain the following expression for the aggregate price index

$$1 = \left(\int_0^1 (\tilde{p}_{st})^{1-\eta} ds \right)^{\frac{1}{1-\eta}} \tag{B6}$$

Third, households solve a standard consumption-savings problem. Specifically, they choose total consumption c_t and holdings of one-period nominal bonds (whose real value is denoted by a_t) to maximize expected discounted lifetime utility[B1]

$$U(c_t, h_{jt}) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} - \psi \frac{h_{jt}^{1+\chi}}{1+\chi} \right\}$$

subject to the budget constraint $c_t + a_{t+1}\pi_{t+1} = w_{jt}h_{jt} + (1 + R_{t-1})a_t + \Pi_t$ (expressed in real terms), where R_t denotes the nominal interest rate and Π_t real firm profits which are distributed back lump-sum to households. Optimal household consumption and savings decisions are characterized by the first order conditions

$$\begin{aligned} 1 &= \mathbb{E}_t \left[\frac{1 + R_t}{\pi_{t+1}} m_{t,t+1} \right] \\ m_{t,t+1} &= \beta \frac{c_{t+1}^{-\sigma}}{c_t^{-\sigma}} \end{aligned} \tag{B7}$$

together with a standard transversality condition. The first of the above equations is the Euler equation, while the second represents the stochastic discount factor.

B1.3 Final goods firms

In each industry, a competitive aggregating firm uses a unit continuum of varieties l as inputs to produce the industry composite good y_{st} according to the Kimball (1995) aggregator

$$\int_0^1 \Upsilon \left(\tilde{y}_{lst} \right) dl = 1 \tag{B8}$$

[B1] We deliberately drop the j subscript from consumption and bond holdings. Markets are assumed to be complete, and preferences are separable in consumption and labor supply, and consequently all households will make the same consumption and savings choices.

where $\tilde{y}_{lst} := y_{lst}/y_{st}$ denotes the demand of variety l relative to the total industry output. The profit maximization problem of the final goods firm is given by $\max_{\tilde{y}_{lst}} 1 - \int_0^1 \tilde{p}_{lst}\tilde{y}_{lst}dl$, subject to the aggregator (B8), where $\tilde{p}_{lst} := p_{lst}/p_{st}$ denotes the relative price of variety l with respect to the industry price index. The necessary first order condition is $\tilde{p}_{lst} = \nu_{st}\Upsilon'(\tilde{y}_{lst})$, where ν_{st} denotes the Lagrange multiplier on the constraint. We specifically use the commonly adopted aggregator from Dotsey and King (2005) which is given by

$$\Upsilon\left(\tilde{y}_{lst}\right) = \frac{\theta}{\theta(1-\varepsilon)-1}\left[\left((1-\varepsilon)\tilde{y}_{lst}+\varepsilon\right)^{1-\frac{1}{\theta(1-\varepsilon)}}-1\right]+1$$

where $\theta > 0$ denotes the average demand elasticity, and $\varepsilon \geq 0$ governs the superelasticity of demand, i.e. how the demand elasticity varies with relative demand $\tilde{y}_{lst}$. With this functional form, the demand curves become

$$\tilde{y}_{lst} = \left[\left(\frac{\tilde{p}_{lst}}{\nu_{st}}\right)^{-\theta(1-\varepsilon)} - \varepsilon\right]\frac{1}{1-\varepsilon} \tag{B9}$$

Substituting into the aggregator and solving for $p_{st}\nu_{st}$ then gives

$$p_{st}\nu_{st} = \left[\int_0^1 p_{lst}^{1-\theta(1-\varepsilon)}dl\right]^{\frac{1}{1-\theta(1-\varepsilon)}}$$

Using the zero profit condition of the final goods producer, given by $p_{st}y_{st} = \int_0^1 p_{lst}y_{lst}dl$, as well as the demand curves, we can solve for the sectoral price index

$$\begin{aligned} p_{st} &= \int_0^1 p_{lst}\tilde{y}_{lst}dl \\ &= \frac{1}{1-\varepsilon}\left[\int_0^1 p_{lst}^{1-\theta(1-\varepsilon)}dl\right]^{\frac{1}{1-\theta(1-\varepsilon)}} - \frac{\varepsilon}{1-\varepsilon}\left[\int_0^1 p_{lst}dl\right] \end{aligned} \tag{B10}$$

B1.4 Intermediate goods firms

Intermediate goods firms in each industry use labor h_{lst} to produce according to the technology

$$y_{lst} = h_{lst} \tag{B11}$$

Production is subject to the capacity constraint

$$y_{lst} \leq q_{lst} \tag{B12}$$

where q_{lst} denotes the firm's total production capacity. Capacity is potentially varying across firms, but is fixed across industries and over time for simplicity. In other words, it is pinned down by the exogenous parameter $q_{lst} = \xi_l$. All nominal price changes are subject to the Rotemberg (1982) adjustment cost

$$\mathcal{C}_{lst} = \frac{\gamma_p}{2}\left(\frac{p_{lst}}{p_{lst-1}} - 1\right)^2 \tilde{p}_{st} y_{st} = \frac{\gamma_p}{2}\left(\frac{\tilde{p}_{lst}}{\tilde{p}_{lst-1}}\pi_{st} - 1\right)^2 \tilde{p}_{st} y_{st}$$

where $\pi_{st} := p_{st}/p_{st-1}$ denotes the inflation rate of industry s. The Lagrangian of the intermediate goods firm's profit maximization problem can now be written as

$$\begin{aligned}\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} m_{0,t} \Bigg\{ & \tilde{p}_{lst}\tilde{p}_{st} y_{lst} - w_t h_{lst} - \mathcal{C}_{lst} \\ & + \omega_{lst}\left[y_{st}\left(\left(\frac{\tilde{p}_{lst}}{\nu_{st}}\right)^{-\theta(1-\varepsilon)} - \varepsilon\right)\frac{1}{1-\varepsilon} - y_{lst}\right] \\ & + \lambda_{lst}\left[q_{lst} - y_{lst}\right] \\ & + \kappa_{lst}\left[h_{lst} - y_{lst}\right] \Bigg\}\end{aligned}$$

where $m_{0,t}$ denotes the stochastic discount factor. The first order conditions ($\tilde{p}_{lst}$, y_{lst},h_{lst}) yield

$$\begin{aligned} mc_{lst} &:= \kappa_{lst} = w_t \\ \tilde{p}_{lst} = \ \mu_{lst}(\tilde{y})\frac{(mc_{lst} + \lambda_{lst})}{\tilde{p}_{st}} &+ \frac{\gamma_p}{\zeta_{lst}(\tilde{y}) - 1}\mathbb{E}_t\left[m_{t,t+1}\left(\pi_{lst+1} - 1\right)\pi_{lst+1}\frac{y_{st+1}}{y_{lst}}\frac{\tilde{p}_{st+1}}{\tilde{p}_{st}} - \left(\pi_{lst} - 1\right)\frac{\pi_{lst}}{\tilde{y}_{lst}}\right] \end{aligned} \tag{B13}$$

with $\pi_{lst} := \tilde{p}_{lst}/\tilde{p}_{lst-1}\pi_{st}$ denoting the inflation rate of variety l in industry s, and $\mu_{lst}(\tilde{y})$ pinned down by the demand elasticity $\zeta_{lst}(\tilde{y})$ according to $\mu_{lst}(\tilde{y}) := \zeta_{lst}(\tilde{y})/(\zeta_{lst}(\tilde{y}) - 1)$. The first equation specifies the firm's real marginal cost as given by κ_{lst}, while the second equation stipulates the optimal price setting behavior. The demand elasticity is defined by

$$\begin{aligned}\zeta_{lst}(\tilde{y}) :&= -\frac{\partial \ln \tilde{y}_{lst}}{\partial \ln \tilde{p}_{lst}} \\ &= -\frac{\partial \tilde{y}_{lst}}{\partial \tilde{p}_{lst}}\frac{\tilde{p}_{lst}}{\tilde{y_{lst}}} \\ &= \theta \tilde{p}_{lst}^{-\theta(1-\varepsilon)-1}(\nu_{st})^{\theta(1-\varepsilon)}\frac{\tilde{p}_{lst}}{\tilde{y}_{lst}} \\ &= \theta\left(1 + \varepsilon\frac{1 - \tilde{y}_{lst}}{\tilde{y}_{lst}}\right)\end{aligned}$$

B1.5 Monetary authority

The central bank sets the nominal interest rate according to the Taylor rule

$$R_t = (1 + R_{t-1})^{\phi_R} \left((1 + \overline{R})(\pi_t)^{\phi_\pi} \right)^{1-\phi_R} \exp(\mathcal{M}_t) - 1 \tag{B14}$$

where the exogenous shock component $\mathcal{M}_t$ evolves according to an AR(1) process with mean zero, persistence ρ_R, and volatility σ_R. Furthermore, $\overline{R} = 1/\beta - 1$ denotes the steady state level of the nominal interest rate.

B1.6 Aggregation and equilibrium

The market clearing conditions for the labor market, asset market, and the goods market in each industry s, are respectively given by

$$\begin{aligned} h_t &= \sum_s \int_0^1 h_{lst} dl \\ a_{t+1} &= 0 \\ \tilde{p}_{st} c_{st} &= \int_0^1 \tilde{p}_{lst} \tilde{p}_{st} y_{lst} dl - \int_0^1 \mathcal{C}_{lst} dl \qquad \forall s \end{aligned}$$

We now restrict our attention to a setup with a finite number of industries S, and a finite number N_s of distinct firm types within each industry, denoted by k, which potentially differ in their level of ξ_k. Since this is the only source of heterogeneity, all firm choices will be symmetric within each (k, s) combination. Consequently, we can use equation (B10) to obtain the following expressions for the sectoral inflation rates

$$\begin{aligned} \pi_{st} &= \frac{1}{p_{st-1}} \left(\frac{1}{1-\varepsilon} \left[\sum_k \int_{l \in \mathcal{G}_{ks}} p_{lst}^{1-\theta(1-\varepsilon)} dl \right]^{\frac{1}{1-\theta(1-\varepsilon)}} - \frac{\varepsilon}{1-\varepsilon} \left[\sum_k \int_{l \in \mathcal{G}_{ks}} p_{lst} dl \right] \right) \\ &= \frac{1}{1-\varepsilon} \left[\sum_k \Omega_{ks} (\tilde{p}_{kst-1} \pi_{kst})^{1-\theta(1-\varepsilon)} \right]^{\frac{1}{1-\theta(1-\varepsilon)}} - \frac{\varepsilon}{1-\varepsilon} \left[\sum_k \Omega_{ks} \tilde{p}_{kst-1} \pi_{kst} \right] \end{aligned}$$

where $\mathcal{G}_{ks}$ denotes the set of firms of type k in industry s and $\Omega_{ks} := \int_{l \in \mathcal{G}_{ks}} dl$ its mass, with $\sum_k \Omega_{ks} = 1$, and $\pi_{kst} := \tilde{p}_{kst} / \tilde{p}_{kst-1} \pi_{st}$ and $\pi_{st} := \tilde{p}_{st} / \tilde{p}_{st-1} \pi_t$ respectively denote firm- and industry-specific inflation rates. Equivalently, we can rewrite the expression for the aggregate inflation rate from equation (B6) as $\pi_t = \left(\sum_{s=1}^S \omega_s (\tilde{p}_{st-1} \pi_{st})^{1-\eta} \right)^{\frac{1}{1-\eta}}$, where ω_s denotes the mass of industry s, with $\sum_{s=1}^S \omega_s = 1$. Moreover, from equation (B8) we obtain the the sectoral

Kimball (1995) aggregator

$$1 = \sum_k \Omega_{ks} \left(\frac{\theta}{\theta(1-\varepsilon)-1} \left[((1-\varepsilon)\tilde{y}_{kst} + \varepsilon)^{1-\frac{1}{\theta(1-\varepsilon)}} - 1 \right] + 1 \right)$$

We introduce an auxiliary definition for gross aggregate output, y_t, given by $y_t = \sum_s \omega_s \tilde{p}_{st} y_{st}$. Finally, the market clearing conditions reduce to

$$\begin{aligned} h_t &= \sum_s \sum_k \Omega_{ks} h_{kst} \\ \tilde{p}_{st} c_{st} &= \sum_k \Omega_{ks} \tilde{p}_{kst} \tilde{p}_{st} y_{kst} - \sum_k \Omega_{ks} \mathcal{C}_{kst} \qquad \forall s \end{aligned}$$

The full equilibrium is characterized by the endogenous variables y_{kst}, y_{st}, y_t, $\tilde{p}_{kst}$, $\tilde{p}_{st}$, π_{kst}, π_{st}, π_t, ν_{st}, h_{kst}, h_t, w_t, w_t^* mc_{kst}, λ_{kst}, c_{st}, c_t, a_{t+1}, $m_{t,t+1}$, and R_t, and equations (B3), (B4), (B5), (B7), (B9), (B11), (B12), (B13), (B14), the four market clearing conditions, the equations for aggregate inflation, sectoral inflation, and the Kimball (1995) aggregator as specified above, and the definitions for π_{kst}, π_{st}, and y_t. In sum, this constitutes a system of $9 + \sum_s (N_s 6 + 5)$ equations and $9 + \sum_s (N_s 6 + 5)$ endogenous variables. In the special case of $\eta = 1$, note that the consumption aggregator reduces to the Cobb-Douglas expression

$$c_t = \prod_s c_{st}^{\omega_s}$$

Consequently, the aggregate inflation rate can be written as

$$\pi_t = \prod_s (\tilde{p}_{st-1} \pi_{st})^{\omega_s}$$

B1.7 Solution method

We solve the model by applying the piecewise linear solution method proposed by Guerrieri and Iacoviello (2015). Specifically, this method takes a piecewise linear approximation of the model with respect to occasionally binding constraints, which in our model are the capacity constraints, and a linear approximation with respect to any other nonlinearities. In practice, we implement the method via Dynare's OccBin routine. This routine only allows for two occasionally binding constraints and, hence, we assume that constrained firms always remain constrained. Since we only consider an expansionary monetary policy shock in the baseline analysis, which makes the capacity constraint more binding for all firms, this will not affect the results. We have also

verified that the simulation exercises executed to compute the implied slope of the Phillips curve are not affected by this choice. The model is solved with Dynare version 5.5 and Matlab version R2024A.

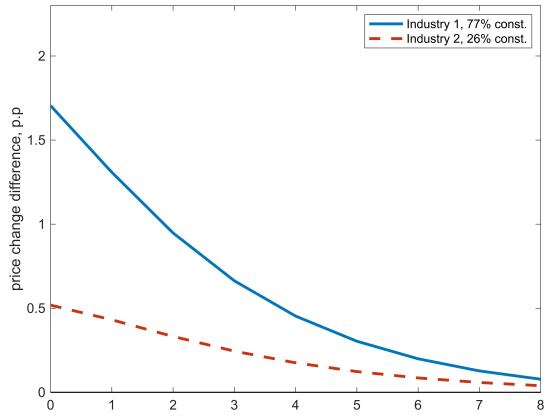
B2 Robustness

This section presents robustness checks for the model. Figure B1 displays the difference in price responses between constrained and unconstrained firms in industries with a high and low share of constrained firms, respectively, (i.e., the equivalent of the lower right panel of figure 8), when assuming that the industry composite goods are substitutes ($\eta = 1.5$) or Cobb-Douglas ($\eta = 1$), instead of complements ($\eta = 0.5$) as in the baseline calibration. The left column shows impulse responses when allowing for strategic complementarities in price setting ($\varepsilon > 0$), while the right column shuts down this feature of the model ($\varepsilon = 0$). Next, figure B2 presents the same results when extending the Taylor rule (B14) to include also the output gap. Specifically, the nominal interest rate is now set according to

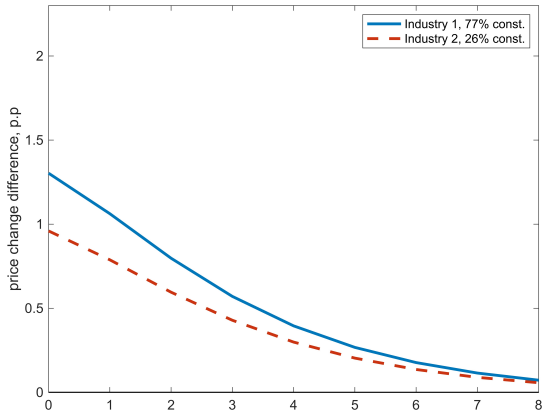
$$R_t = (1 + R_{t-1})^{\phi_R} \left((1 + \overline{R}) \left(\frac{Y_t}{\overline{Y}} \right)^{\phi_Y} (\pi_t)^{\phi_\pi} \right)^{1-\phi_R} \exp(\mathcal{M}_t) - 1$$

where $Y_t = c_t$ and $\overline{Y}$ denote aggregate output and its steady state level, respectively, and $\phi_Y = 0.125$ is the Taylor rule coefficient on the output gap. As can be seen in figures B1 and B2 below, when adjusting either the substitutability between the industry composite goods or the Taylor rule the results remain very close to those of our baseline model.

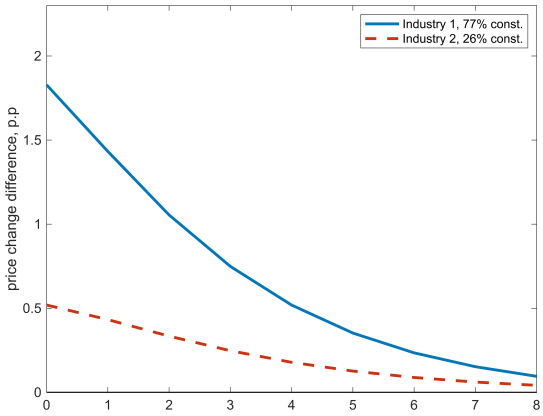
Figure B1: Robustness: industry elasticity η



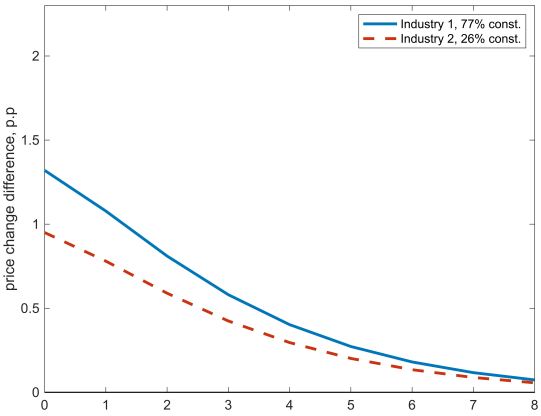
(a) $\eta > 1, \varepsilon > 0$



(b) $\eta > 1, \varepsilon = 0$

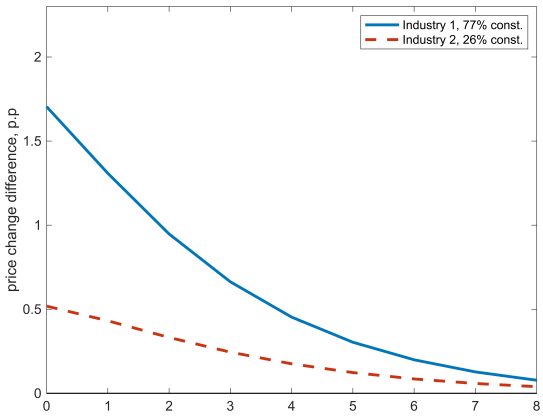


(c) $\eta = 1, \varepsilon > 0$

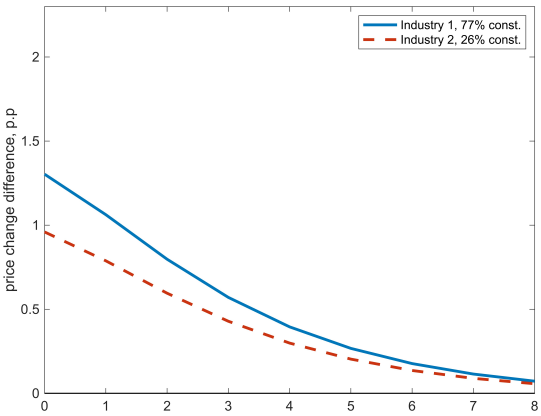


(d) $\eta = 1, \varepsilon = 0$

Figure B2: Robustness: Taylor rule



(a) $\varepsilon > 0$



(b) $\varepsilon = 0$