Price Setting Along the Supply Chain: Evidence from PPI and CPI Microdata

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July 18, 2025

Abstract

This paper brings novel evidence on nominal and real rigidities along the supply chain using a unique and comprehensive microdata dataset of monthly firm-product level prices covering the entire Canadian supply chain. We document a new set of stylized facts regarding price-setting behaviors along the whole supply chain. We then contrast the adjustments of nominal and real rigidities along the supply chain to both monetary policy and cost-push shocks, whose relevance has resurged in the wake of the COVID-19 pandemic. We find prices respond stronger and faster to monetary tightening in upstream sectors (manufacturing, wholesale, retail) than consumer prices (CPI), with falling markups strengthening the transmission of monetary policy. Similarly, more flexible upstream than downstream prices combined with rising margins in the wholesale and retail sectors contribute to amplify the effect of supply shocks on consumer prices. This pattern aligns with the responses of the CPI to these shocks.

Keywords: *nominal and real rigidities, monetary policy transmission, inflation surge, micro-level data*

JEL Classification: D22; E31; C22; E52.

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1 Introduction

Understanding how nominal and real rigidities shape inflation dynamics along the business cycle is central to macroeconomic modeling and policy design.[1] Countercyclical markups in the presence of sticky prices, as posited in the standard New Keynesian literature [Clarida et al., 1999], enhance the effectiveness of demand-side policies, while procyclical or acyclical patterns can blunt it. Price-setting behaviors have therefore first-order implications for monetary policy transmission, fiscal multipliers, and the welfare costs of fluctuations. Yet, despite their central importance, empirical evidence on how these behaviors vary over the business cycle and affect the transmission of monetary policy remains scarce – all the relevant literature is surveyed hereafter.

Given the prevailing theoretical paradigm in an overall context of low and stable inflation, the empirical literature on real rigidities has focused almost exclusively on the transmission of demand shocks, with mixed empirical evidence on the cyclicality of markups. The recent inflationary context has brought back to the forefront the importance of price shocks [Bernanke and Blanchard, 2025]. Real and nominal rigidities affect how these shocks are absorbed along the whole supply chain, down to the consumer prices that central banks are concerned with. Whether the intermediate chain acts as a buffer or amplifier to these shocks down to the consumers depends not only on the flexibility of nominal prices, but crucially on how margins adjust. Therefore, understanding the transmission of shocks to the economy requires the study of price-setting along the entire supply chain.

However, empirical evidence supporting nominal rigidities – in particular the study of the frequencies and sizes of price changes at the firm or sector levels – rely on consumer price index (CPI) data, leaving price formation along the rest of the supply chain essentially

[1] Nominal rigidities refer to frictions that prevent prices (or wages) from adjusting immediately to changes in economic conditions. These include sticky prices, menu costs, or staggered price-setting, and are central in the New Keynesian models to generate non-neutral effects of monetary policy. By contrast, real rigidities arise when firms' desired relative prices or markups respond sluggishly to economic shocks, often due to strategic complementarities in pricing, adjustment costs in production, or market power [Ball and Romer, 1990].

unexplored. In models, nominal rigidities are often assumed to be uniform and constant over the business cycle. However, growing empirical evidence points to significant heterogeneity across sectors and levels of the supply chain. Additionally, most of the insights on nominal rigidities in the face of supply shocks and inflation surges draw on the 1970s and 1980s experience. Sparse recent evidence suggest that nominal rigidities are partly state-dependent, at least in the CPI, making prices more flexible and enhancing the pass-through of shocks to consumer prices, and weakening the real effects of monetary policy when inflation is high. Finally, there is little to no research based on micro-level price data in small open economies (SOE) because the majority of the literature uses US or Euro-zone data.

To understand inflation dynamics in the wake of the COVID-19 pandemic, it is therefore crucial to understand how both demand and supply shocks travel down the supply chain. The data suggests that the sensitivity of prices to shocks differs along the supply chain, and has shifted since the onset of the COVID-19 pandemic; see an illustration in Fig. 1 for the case of Canada, a SOE. While the pre-pandemic inflation-unemployment relationships are generally flat, post-pandemic slopes steepen down the supply chain, which suggests a loosening of nominal rigidities (e.g. more frequent or larger price changes, an increased use of state-dependent pricing strategies in response to heightened uncertainty), a reduction in real rigidities (e.g., a strengthening of the pass-through of shocks along the supply chain), or both. This picture clearly motivates a closer examination of how upstream and downstream prices adjust in response to shocks.

This paper brings novel evidence on nominal and real rigidities by exploiting a unique microdata dataset of monthly firm-product level prices covering the entire Canadian supply chain over the recent period – from manufacturing, to wholesale and retail prices, down to consumer prices. By analyzing both CPI and PPI data in a unified framework, we provide a comprehensive view of price-setting behaviors across sectors and contrast their responses to demand and supply shocks. By combining differences in nominal rigidities with the dynamics of markups along the supply chain, we shed light on the sources of inflation persistence.

Shocks take time to hit the CPI because since they travel down the supply chain where adjustments in wholesale and retail margins affect the pace and magnitude of transmission.

Our main results are as follows. We first provide a set of stylized facts regarding price-setting behavior along the supply chain and the business cycle. We uncover substantial heterogeneity in both nominal adjustments and the implied behavior of markups along the supply chain. In detail, price changes are more frequent and more heterogeneous across product-firms upstream than downstream. But price changes are larger and more heterogeneous downstream than upstream, with the difference has considerably shrunk since the onset of the recent inflation surge. During this episode, downstream price increases stem mainly from persistently higher adjustment frequencies (in line with the CPI literature survey below), while upstream increases also reflect larger price changes. Additionally, wholesale markups are lower than markups in the retail sector but the gap has also persistently narrowed since 2021 following a particularly sharp and lasting increase in wholesale markups.

We then dive into how the different dimensions of nominal and real rigidities adjust to different types of shocks. While nominal rigidities respond to supply shocks fairly similarly along the supply chain, driven by more frequent price changes, we find heterogeneous responses of to monetary policy shocks. Price responses are faster and larger in the wholesale sector, driven by both more frequent and larger price changes, while responses are delayed and smaller downstream (retail and CPI), driven almost exclusively by adjustments in price change frequencies. As for real rigidities, in the wake of monetary tightening, wholesale markups decline, which contributes to strengthen the transmission of monetary policy to the CPI. Retail markups remain fairly unaffected by the demand shock. By contrast, markups increase in both segments and with a similar magnitude following an oil price shock.

Hence, both nominal and real rigidities contribute to the transmission of monetary policy down the supply chain to the CPI. Prices appear more flexible upstream than downstream, and falling markups contribute to overall strengthen the transmission of monetary tightening earlier in the supply chain. Similarly, in the face of supply shocks, the combination of more

flexible upstream than downstream prices and rising margins in the wholesale and retail sectors contribute to amplify the inflationary effects of these shocks on the CPI.

Our results inform macroeconomic modeling for policy design and forecasting by emphasizing heterogeneous real and nominal rigidities across sectors, drawing the implications of this heterogeneity on the transmission of monetary policy down to the CPI, and highlighting the distinct and substantial effects of supply shocks on inflation dynamics.

The rest of the paper is organized as follows. After the review of the related literature, Section 2 describes the data and provides a set of stylized facts, Section 3 contrast the responses of nominal and real rigidities to shocks, and Section 4 concludes with the implications of our work.

1.1 Related literature

This paper relates to the empirical literature on price stickiness. We document new findings on heterogeneity in price rigidities across sectors and over time for Canada using both producer and consumer price microdata. Bils and Klenow [2004], Nakamura and Steinsson [2008], and Klenow and Kryvtsov [2008] are among the first studies to document average price durations of 4–12 months in the U.S. using CPI and PPI microdata. Nakamura and Steinsson [2008] find similar price rigidity in finished-goods producer prices and in regular consumer prices. As regards evidence for Canada, Kryvtsov [2016] reports similar frequency estimates from CPI microdata. However, studies examining both consumer and producer micro price data remain scarce. In addition, there is limited evidence available for Canada, especially at producer level.

Some studies report significant heterogeneity in price dynamics along the supply chain. Nakamura and Steinsson [2008] find that median frequency of price changes is slightly higher for intermediate goods than for finished goods (13.3 percent versus 10.8 percent), and substantially higher for raw materials (close to 100 percent). Nakamura [2008] studies the co-movement of prices across products, stores and locations to assess the relative importance

of retailers versus manufacturers in price setting. The paper finds that most of the observed price variation arises from retail-level rather than manufacturer-level demand and supply shocks. More recently, Gautier and Le Bihan [2022] finds substantial cross-sectoral heterogeneity in price rigidity using CPI microdata. We contribute to this literature by comparing pricing moments from wholesalers, retailers and consumer prices to better understand dynamics in price setting at different stages of the supply chain. Similar to Alvarez et al. [2024], we find that manufacturers and retailers adjust their markups differently. This analysis has important implications for monetary policy transmission. In particular, several studies show that sectoral heterogeneity in price stickiness amplifies the aggregate effects of monetary policy shocks, notably Nakamura and Steinsson [2010], Pasten et al. [2020] and Carvalho and Kryvtsov [2021].

While earlier studies primarily focus on low-inflation contexts, the surge in inflation following the COVID-19 pandemic sparked new interest in understanding changes in price setting behavior during high-inflation episodes. For the U.S., Montag and Villar [2023, 2025] document that the surge in inflation was mainly driven by a large increase in the frequency of price increases. Grimaud et al. [2024] and Bilyk et al. [2024] report similar findings using consumer micro price data for the Euro Area and for Canada, respectively. Using micro-level data for the manufacturing sector, Gagliardone et al. [2025] provide evidence that firms are more likely to adjust prices as the gap between their listed and optimal price widens. These patterns are consistent with state-dependent pricing, where the probability of price adjustments increases as the gap between the actual price and the firm's desired price widens. We provide further evidence of state-dependency in price setting of Canadian firms, using micro price data that covers the most recent high inflation period, by decomposing inflation into extensive and intensive margins, similar to Nakamura et al. [2018], and by estimating the impact of aggregate shocks on several pricing moments. At the aggregate level, these findings imply a nonlinear cost-price passthrough, which is higher when shocks are large (see Gagliardone and Tielens [2024], Tielens et al. [2024]).

2 Data

We use a comprehensive set of monthly consumer and producer price micro-level data from Statistics Canada that covers the whole supply chain from upstream (producer prices) to downstream (consumer prices); see Fig. 2 for a schematic representation. We use the micro-level data from the Industrial Production Price Index (IPPI), the Wholesale Services Price Index (WSPI), the Retail Services Price Index (RSPI), and the Consumer Price Index (CPI) over the period 2014M1 to 2024M12.

2.1 Data sources

The IPPI survey tracks monthly price changes for key commodities sold by Canadian manufacturers at the factory gate, i.e. the amount received by producers excluding any indirect taxes, tariffs, transportation or distribution costs, wholesale or retail markups, or other final costs that impact downstream prices. The IPPI targets all manufacturing establishments operating in Canada, for both domestic and export markets. It serves as a key indicator of the manufacturing sector's economic performance and supports the calculation of real GDP within the Canadian System of Macro-Economic Accounts. IPPI is based on the North American Product Classification System (NAPCS). Data are collected from approximately 1,000 manufacturers across Canada, which represents around 3,360 price quotes each month.

Prices of wholesalers and retailers come from Statistics Canada's monthly surveys: the WSPI survey, which covers all establishments classified under NAICS 41 (wholesale trade), and the RSPI survey, which covers all businesses with at least one retail establishment (NAICS codes 44-45), excluding 'Automobile and Other Motor Vehicle Dealers' and 'Non-Store Retailers.' Respondents report both the average monthly purchase prices (i.e., the amounts paid for the acquisition of a given product) and selling prices (i.e., the amounts received for selling the same product), excluding taxes. Prices are reported for up to six

pre-selected products in the WSPI and 12 products in the RSPI, based on their contribution to annual sales or frequency of purchases/sales throughout the year.

All producer datasets include sampling weights that are used throughout the analysis to account for the relative economic importance of the firms in the population. Weight updates for the producer price datasets occurred as follows: for the IPPI, in July 2014, January 2020, and August 2024; for the WSPI, in January 2016 and December 2021; for the RSPI, in January 2014 and September 2023.

The consumer price dataset includes approximately 100,000 individual price quotes for goods and services per month. The dataset accounts for about 60% of Canada's CPI. Prices are collected from a wide range of retail environments – including grocery stores, specialty retailers, service providers, and other commercial outlets – located across up to 92 urban centers in Canada. Outlet selection is generally based on sales volume, with considerations for regional representation and outlet type. Our analysis excludes the shelter portion because Statistics Canada's methodology for measuring housing prices differs from that used for retail goods and services. The dataset includes proportional basket weights per commodity derived from the Survey of Household Spending at the national level. Since 2011, basket updates have occurred biennially and starting in 2022, annually.

2.2 Price changes and markup proxies

Statistics Canada applies various error-detection procedures and excludes anomalies and some outliers. Price changes are carefully reviewed to ensure they are not driven by structural changes such as product reclassifications or unit changes. Additionally, we apply the following cleaning procedures to define price changes and approximate markups.

In each month in all datasets, we compute the price change between two consecutive month for each product quote. We define price changes as those strictly greater than 1% in absolute value, and exclude observations with price increases greater than 900% or price

decreases greater than 90% in absolute value between consecutive months.[2]

We drop observations where the price is missing, zero, or negative and where the price is reported in a currency other than Canadian dollars. The producer price datasets include two important flag variables: a "non comparable" flag and an "exclude" flag. A product is considered "comparable" to its previous version if it serves the same function, has similar characteristics and prices, and targets the same niche market. The "exclude" flag identifies outlier observations based on patterns observed for that particular firm-product in the surrounding periods. We exclude observations flagged as either "exclude" or "non-comparable."

In WSPI and RSPI, we approximate markups at the firm-product level with the (log) ratio of the selling prices to the purchase prices, which can be used as a proxy for the unobserved marginal costs.[3] We exclude observations where the markup is less than one (i.e., the selling price is lower than the purchase price), and where the change in the margin price (i.e., the difference between the selling and the purchasing prices) exceeds a factor of 10 between consecutive months. We also drop the top 1% of the markup distribution to mitigate the influence of extreme values.

To deal with the high seasonality and volatility of the data, we perform our analysis using 12-month moving averages.

2.3 Counterfactual inflation rates

Beyond the analysis of sectoral inflation rates, we aim to unpack price-setting behaviors of firms along the supply chain. To do so, we decompose price adjustments into an extensive margin (corresponding to the frequency of price changes), and an intensive margin (corresponding to the size of price changes); see Gautier et al. [2024] and Montag and Villar

[2]This approach follows the related literature; see, e.g., Eichenbaum et al. [2014] or Klenow and Kryvtsov [2008].

[3]See Alexander et al. [2024] for a similar argument on Canadian WSPI data and Gopinath et al. [2011]; Eichenbaum et al. [2011]; Anderson et al. [2018] using price retail data. In what follows, we refer to this proxy as "markup" for readability.

[2025] for a similar approach. Accordingly, we compute the total inflation rate in sector $s = \text{IPPI}, \text{WSPI}, \text{RSPI}, \text{CPI}$ as follows:

$$\Pi_{s,t} = f^+_{s,t} \times dp^+_{s,t} - f^-_{s,t} \times dp^-_{s,t}, \tag{1}$$

where f^+_s, t (resp. f^-_s, t) is the frequency of price increases (resp. decreases) in sector s in month t, and $dp^+_{s,t}$ (resp. $dp^-_{s,t}$) is the magnitude of monthly price increases (resp. decreases) in sector s in month t.

We then define counterfactual inflation rates where either the frequency or the size of price changes is held fixed over time. The fixed-frequency counterfactual inflation represents the inflation that would have prevailed, had only the size of price changes varied. For any sector s we compute it as:

$$\Pi^{freq}_{s,t} = f^+_s \times dp^+_{s,t} - f^-_s \times dp^-_{s,t}, \tag{2}$$

where f^+_s (resp. f^-_s) is the average frequency of price increases (resp. decreases) in sector s during the pre-pandemic period 2014M01–2019M12, which we use as a proxy for their steady state levels.

Similarly, the fixed-size counterfactual inflation is the inflation that would have prevailed had only the frequency of price adjustments changed, and is defined by:

$$\Pi^{size}_{s,t} = f^+_{s,t} \times dp^+_s - f^-_{s,t} \times dp^-_s \tag{3}$$

where dp^+_s (resp. dp^-_s) is the average magnitude of price increase (resp. decrease) in sector s over 2014M01–2019M12.

2.4 Descriptive statistics

We present the following price-setting statistics for each sector in Table 1 and Figure 3 over the period 2014M1–2024M12: (i) the frequency of price changes, which is the share (in percent) of prices that change each month; (ii) the size of price changes, which is the average monthly price change (in percent); (iii) the dispersion of price changes, measured as the standard deviation of monthly price changes;[4] and iv) the markups. The first three statistics speak to nominal rigidities, while the fourth ones summarizes real rigidities.

Starting with the frequencies of price changes, overall, between 23 and 42% of prices change from one month to the next, with more flexible prices upstream (IPPI, WSPI) than downstream (RSPI), and the CPI in between (Panel A of Table 1). There is also more volatility in the frequencies of price changes upstream than further down the supply chain. In all sectors, price increases are more frequent than price decreases (see Table B.1).

Since the post-pandemic inflation surge in 2021Q2, price increases have become strikingly more frequent (Figure 3a). Downstream, the frequency of price changes is still on an upward trend (see the RSPI blue dashed line) or has stabilized above its pre-inflation surge level (see the CPI green line), whereas in the WSPI and IPPI, frequencies of price changes have fallen back to their 2019 levels (see the light dashed blue and red dotted lines).

As expected, the average monthly price changes are positive, which shows that prices increase on average, from about 0.7% in the IPPI and RSPI, to 1% in the CPI, and 1.26% in the WSPI (see Panel B of Table 1). Overall, price changes are larger downstream than upstream; see Figure 3b. Interestingly, we observe distinct dynamics in the sizes of price changes in the different segments of the supply chain over time. Since the beginning of the COVID-19 pandemic, price changes (in particular price increases) have become larger upstream (IPPI and, even more, WSPI), whereas they have remained fairly stable downstream (RSPI), and even become smaller in the CPI where they have recently stabilized

[4]We further distinguish between price increases and decreases in Appendix in Table B.2, Table B.1, Table B.3.

below their average pre-pandemic level.

Next, the sizes of price changes are more dispersed across product-firm observations downstream than upstream, with the largest in CPI and the smallest in IPPI (see Panel C of Table 1). The dispersion of price changes in the RSPI, WSPI and CPI is similar until 2020 but becomes distinct afterwards (see Figure 3c). The sizes of price changes become (much) more dispersed downstream in the CPI, while the increase in dispersion upstream is (much) smaller. The dispersion in the size of price changes peaks in all sectors around the end of 2022 – early 2023, before returning to pre-pandemic levels, except in the CPI where it remains elevated despite a downward trend.

Turning to the proxies for markups, up until 2020, they are stable in both the wholesale and the retail sectors (see Figure 3d). Over the whole sample, they average 38% in the wholesale sector, below the 50% average in the retail sector (see Panel D of Table 1). Along the post-pandemic inflation surge, wholesale markups increased earlier and by a larger relative magnitude than the retail markups. While retail markups have reached back their pre-pandemic level amid a modest increase, whole-sale margins remain elevated by the end of our sample, without any clear downward trend.

Finally, Figure 4 decomposes total inflation for each sector (given by Eq. (1)) into fixed-frequency and fixed-size counterfactual inflation rates (see, respectively, Eqs. (2) and (3)). The closer the counterfactual fixed-frequency time series is from total inflation, the higher the contribution of the sizes of price changes to total inflation, and vice-versa with the counterfactual fixed-size series and the role of the frequency of price changes.

Before the pandemic, the frequency of price changes (dark blue dashed lines) is the main driver of inflation in all sectors, which remains true in the CPI over the whole sample, where the size of price changes has continued to play little to no role (see the dark solid line in the bottom-right panel). This finding corroborates what the literature has found in other countries (see, again, the literature review).

However, upstream, in particular in the RSPI and the WSPI, the picture is strikingly

different: both frequencies and sizes have contributed to the post-pandemic inflation surge. In manufacturing, the price increase started with larger sizes quickly followed by higher frequencies (top-left panel). In WSPI, both played a similar role in driving the total prices up. The contribution of sizes peaks at the peak of wholesale inflation, before being somewhat offset by less frequent price adjustments along the disinflation (top-left panel). In RSPI, total inflation has been more modest than in the other sectors, driven mostly by larger sizes in price changes since 2023.

These patterns, that we summarize hereafter, suggest that shocks affect price-setting behaviors in each segment of the supply chain distinctly.

Finding 1 (Stylized facts on price-setting behaviors along the supply chain)**.**

(a) Price change frequencies range from 23 to 42% monthly, with more frequent and heterogeneous changes upstream than downstream.

(b) Price changes are on average larger downstream than upstream but since 2020, they have become persistently larger upstream (wholesale), while becoming persistently lower downstream (CPI), with a marked increase in heterogeneity in this sector.

(c) Over the recent inflation surge, downstream price increases are mostly driven by persistently higher frequencies of price changes, while larger price changes have also played a substantial role upstream and continue to do so.

(c) Markups are higher in the retail than in the wholesale sector. While both increased over the post-pandemic inflation surge, wholesale markups increased earlier and by more than retail markups and have not reversed, whereas retail markups have returned to their pre-pandemic level.

We now estimate how nominal and real rigidities adjust in face of shocks.

3 Responses of price-setting behaviors along the supply chain

We first focuses on the adjustment of price-setting behaviors responsible for nominal rigidities, and then discuss the responses of wholesale and retail markups to shocks.

3.1 Estimation strategy

We estimate the dynamic responses of total inflation, fixed-frequency, and fixed-size counterfactual inflation rates in each of the four sectors to aggregate shocks using the following local projection model [Jordà, 2005]:

$$\pi_{s,t+h} = \alpha_h + \beta_h e_t + \sum_k \gamma_{h,k} w_{k,t} + u_t \tag{4}$$

where $\pi_{s,t+h}$ is the inflation rate of interest in sector s at horizon $h \in [0, H]$, and its response to the shock of interest e_t is given by the estimated coefficient β_h. $w_{k,t}$ are control variables including three lags of the dependent variable, and of real output growth, the policy rate and commodity price index, as usual in small open economy models. Shock e_t is orthogonal to other variables.

Canadian monetary policy shocks are identified in Sekkel and Zhang [2024] from a high-frequency identification approach similar to Gertler and Karadi [2015] and Bauer and Swanson [2023] for the US economy. The shocks are available over the sample 1997M1 to 2023M7. Supply shocks are taken from the oil supply news shocks of Känzig [2021], available from 1975M1 and derived from changes in oil futures prices in a tight window around the Organization of the Petroleum Exporting Countries (OPEC) production announcements. We estimate the responses with monthly data from 2014M1 to 2023M7, which is the common sample available for all datasets.

3.2 Responses of price-setting behaviors along the supply chain

Fig. 5 presents the responses of inflation along the supply chain to a 1% monetary policy tightening.[5] Figs. A.1 to A.4 in Appendix provides the responses of the frequency and size

[5]While total inflation is mechanically the sum of the two counterfactual components, its estimated response is not equal to the sum of the estimated responses of the two counterfactuals. Nevertheless, the size and the direction of the responses of each counterfactual are informative of the drivers of the response of total inflation.

of price increase and decrease in each sector.

Focusing first on total inflation (first column), prices fall to a greater extent and sooner upstream than downstream. The CPI takes more than a year to significantly decrease and the response remains around a modest -1% (last row) while wholesale prices fall on impact and continue doing so down to -4% (second row). Industrial and retail prices (resp. first and third rows) take about six months to respond to the monetary policy shock and the magnitude of their responses is similar to the one of the CPI.

The second and third columns of Fig. 5 show the responses of the fixed-frequency and the fixed-size counterfactual inflation rates, i.e. the responses of the size and the frequency of price changes, respectively. Comparing these two columns with the responses of total inflation indicates that the price-setting behaviors, and hence the source of the responses of inflation, differ along the supply chain.

Downstream, in particular in the CPI, price changes become less frequent while the size of their changes is barely affected by the monetary policy shock (see also Figs. A.3 and A.4). The fall in the frequency of price changes initially also drives the decline in wholesale prices, but price changes additionally become more modest after about a year, which then contributes substantially to the delayed accentuation of the drop in wholesale prices (see also Fig. A.2). A similar pattern, albeit not as striking as in the WSPI data, is observed in the producer price data (see also Fig. A.1).

Fig. 6 reports a similar exercise to Fig. 5 with a 10% increase in oil prices (see also Figs. A.5 to A.8). The responses of inflation and price-setting behaviors are more similar along the supply chain than the responses to demand shocks. While all prices rise on impact, the largest responses to the supply shock are in the industrial and consumer prices. Overall, the increase in the frequency of price changes drives the increase in inflation in all sectors. Decreases in the size of price changes also modestly contributes to the rise in inflation downstream, but not upstream.

We gather these findings concerning the adjustment of nominal rigidities as follows:

Finding 2 (Nominal price adjustments to shocks along the supply chain)**.**

(a) Prices respond to monetary policy shocks differently along the supply chain: responses are faster and larger in the wholesale sector, driven by an adjustment of first the frequency of price changes and then their sizes, while responses are delayed and smaller downstream, driven almost exclusively by the adjustment of price change frequencies.

(b) Prices respond to supply shocks fairly similarly along the supply chain: they rise on impact, driven by more frequent price changes, with the largest responses in industrial and consumer prices.

3.3 Responses of markups

We now estimate the responses of real rigidities using the model (4) where the dependent variable is now the average wholesale and retail markups. Figure 7 shows clear differences in the responses of markups to both shocks across the two sectors.

In detail, in response to monetary policy tightening, wholesale markups decline, whereas retail markups remain unchanged, aside from a small increase around nine months after the shock. Decreasing wholesale markups suggest that prices fall less faster than the marginal costs in this sector. Sluggish decreases in upstream prices suggest that upstream sectors contribute to dampen the transmission of the monetary policy tightening down the supply chain, which could partly accounts for the delay observed in the the CPI downward adjustment. (see, again, Figure 5, bottom left-panel).

By contrast, an increase in oil prices leads to higher markups in both sectors, with a slight delay in wholesale and after an initial modest decline in retail. The size of the responses ends up of similar magnitude in both sectors after about 15 months. Rising markups indicate that prices raise faster than marginal costs, that are inflated by the increase in production costs triggered by the oil shock. Therefore, we find that both segments of the supply chain contribute to amplify the effects of price shocks down the supply chain. Indeed, the positive responses of the markups peak around 18 months, a timing that coincides with the second peak in the CPI inflation reported in Figure 6 (bottom-left panel).

Finding 3 (Markup adjustments to shocks along the supply chain)**.**

(a) Markups respond more strongly in the upstream sector (wholesale) than in the downstream sector (retail), in particular to monetary policy shocks.

(b) In response to a demand shock, wholesale markups decline, which contributes to dampen the transmission of monetary policy to the CPI, whereas retail markups show limited movements.

(c) In response to an oil shock, markups increase in both sectors – after only a moderate initial decline in the retail sector, which indicates that both sectors contribute to amplify the effect of price shocks down the supply chain to the CPI.

4 Conclusion

This paper provides new evidence on how demand and supply shocks ripple through the supply chain down to consumer prices. We use detailed Canadian data on both producer and consumer prices to document sectoral differences in nominal rigidities, markup adjustments, and their response to shocks. We find evidence that midstream markups co-move with inflation, which strengthens the transmission of monetary policy and sharpens the effects of supply shocks on consumer prices.

Traditional macroeconomic models and the empirical literature have placed most of the emphasis on demand shocks, especially through the lens of monetary policy, in a context of decades of low and stable inflation. Our results point instead to a significant role for supply shocks and underscore the need to account for input-output linkages and real rigidities across production networks, beyond the traditional demand-focused paradigm of business-cycle analysis. This contribution also fills a major gap in the literature for small open economies such as Canada, where no previous research has connected producer and consumer price behavior using micro data.

Our analysis carries several implications. First, it explains why consumer prices react with delays to the shocks: shocks must pass through multiple layers of the supply chain, where wholesale and retail margins affect the pace of transmission. Second, it clarifies the

relative roles of nominal and real rigidities. Sector-specific differences in nominal rigidities and markup adjustments show that both forms of rigidity matter for the final effect of shocks on downstream prices. Third, our results inform macroeconomic modeling by showing that real rigidities in the goods markets, such as sluggish adjustment of markups, matter greatly, especially when embedded in production networks. Our analysis of the dynamics of margins provide insights for the development of macroeconomic models that can accommodate varying markup adjustment patterns.

Finally, this work contributes to behavioral macroeconomics by drawing attention to firms. While most existing survey and experimental research has focused on households, our analysis reveals how firm behavior shapes aggregate dynamics in crucial ways. Our stylized facts and the price adjustment mechanisms that we unpack provide a foundation for new data collection and experimental work that places firms at the center of the analysis.

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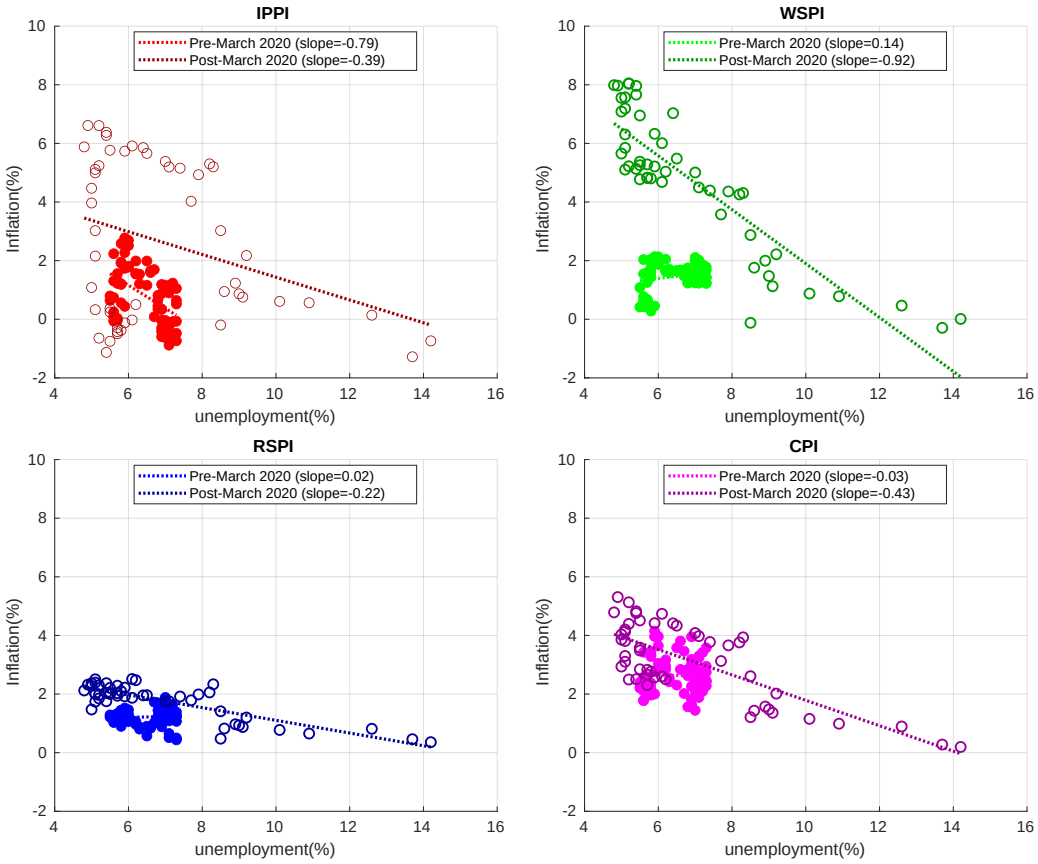
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Figures and Tables



Notes: Each panel displays a scatterplot of monthly sector-specific inflation rates against national unemployment rates for manufacturing (top left), wholesale (top right), retail (bottom left), and CPI (bottom right). Observations from March 2020 onward are marked with hollow circles. Best-fit regression lines are shown separately for the pre- and post-March 2020 periods.

Figure 1: Sector-specific inflation rates vs. unemployment rates

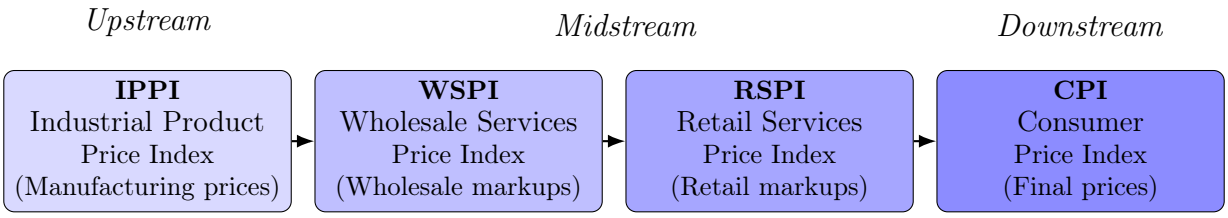
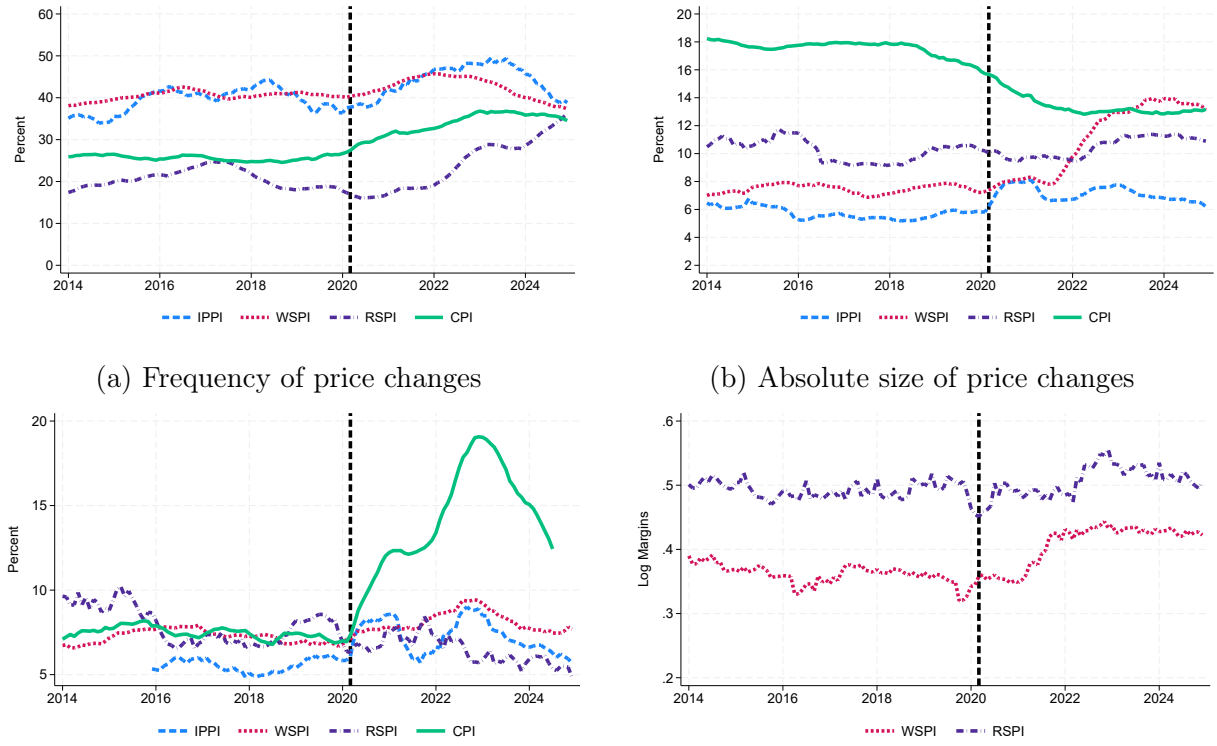


Figure 2: Schematic representation of the price datasets along the supply chain



(a) Frequency of price changes

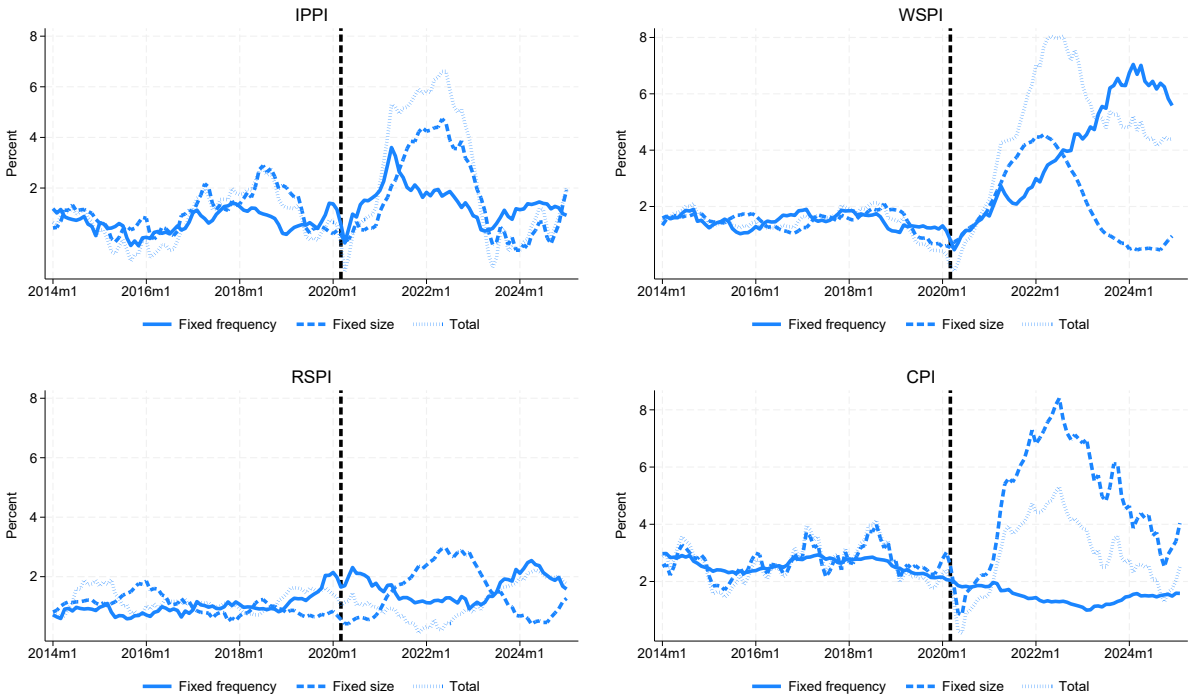
(b) Absolute size of price changes

(c) Interquartile range of price changes

(d) Markups (proxy)

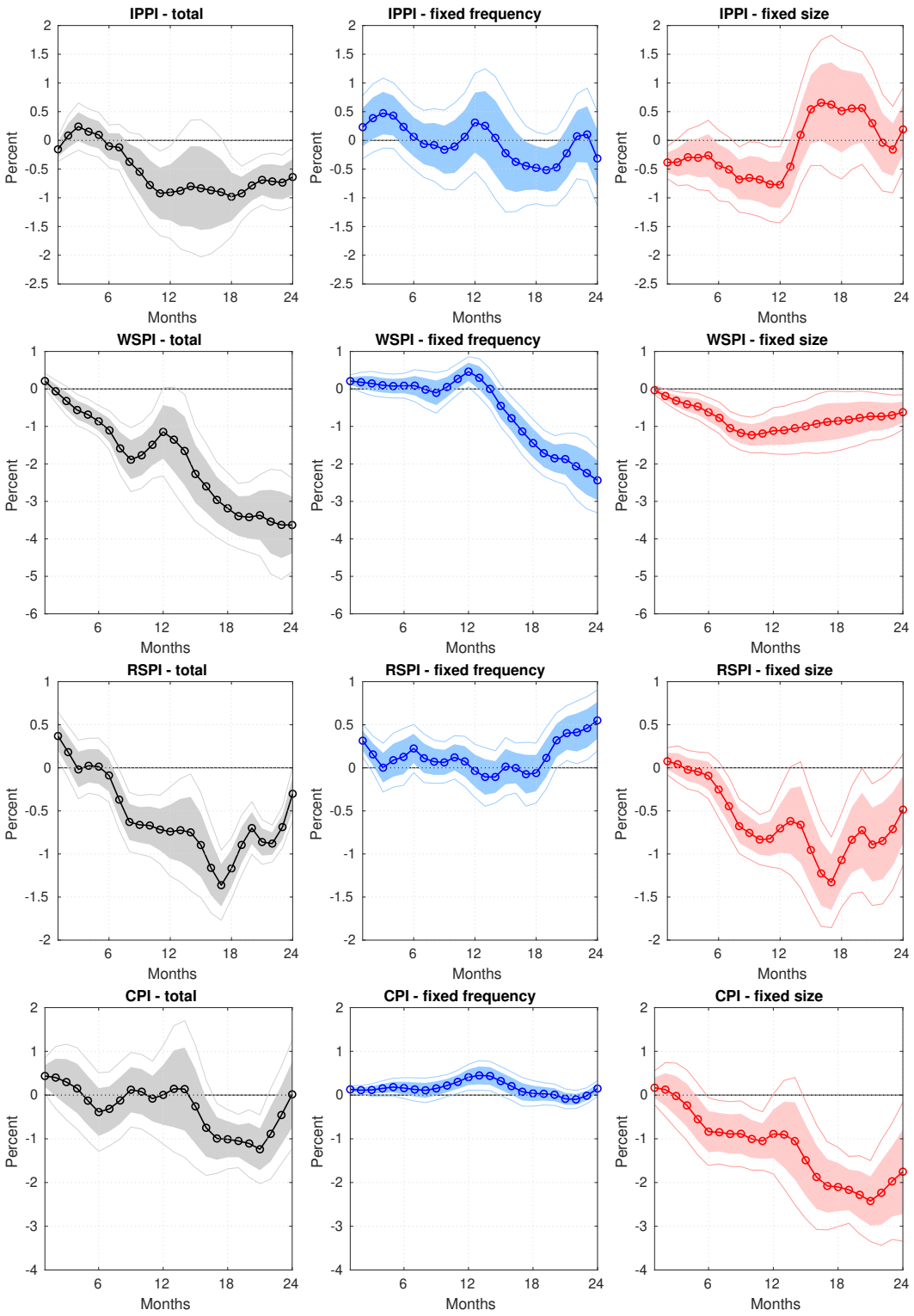
Notes: 12-month moving average. The dotted vertical line denotes the onset of the COVID-19 pandemic. Panel c: the time series of the IQR in the IPPI starts in 2016 due to an insufficient number of observations earlier, which violates StatCan vetting rules for export.

Figure 3: Dynamics of price changes and markups, 2014M1-2024M12



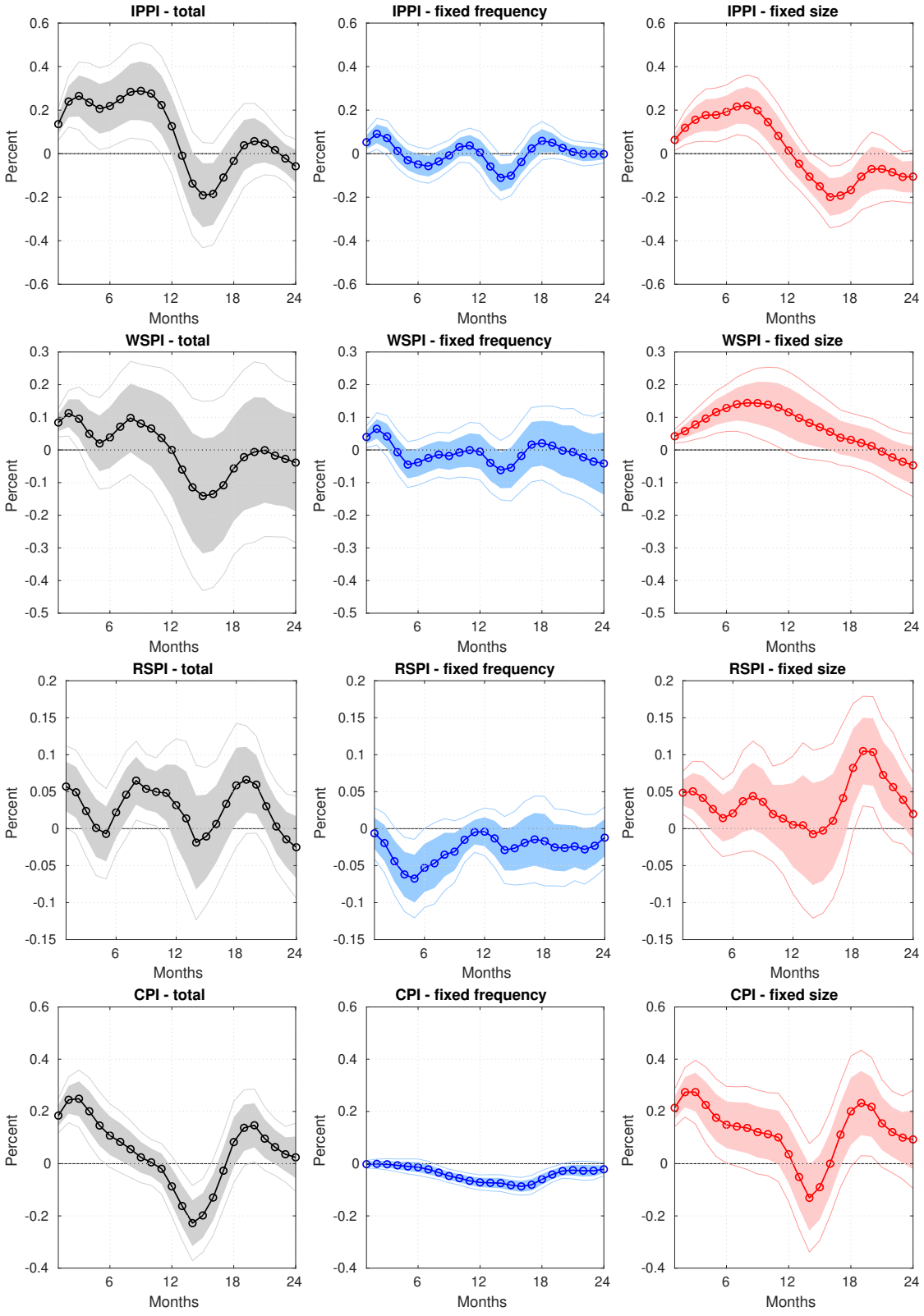
Notes: total and counterfactual inflation rates computed under a fixed-frequency or a fixed-size assumption; 12-month moving average. from top to bottom: manufacturing, wholesale, retail, and CPI.

Figure 4: Counterfactual inflation time series, 2014M1-2024M12



Notes: 90% and 68% confidence intervals; responses of realized inflation rates (first column), counterfactual inflation rates holding the frequency of price changes fixed (second column), of holing the size of price changes fixed (third column). From top to bottom: manufacturing wholesale, and retail sectors, CPI.

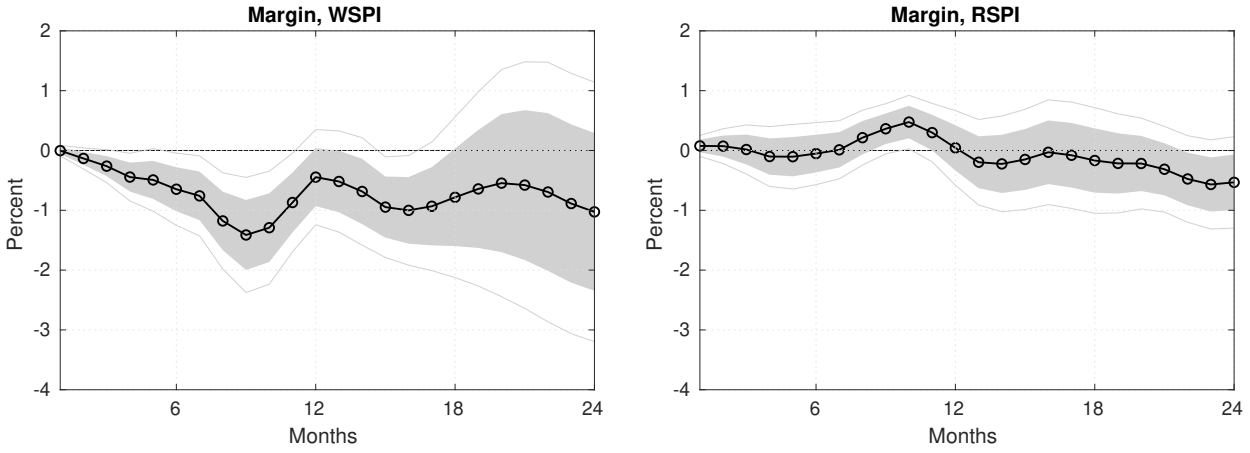
Figure 5: Responses of inflation rates to a 1% monetary policy shock (tightening)



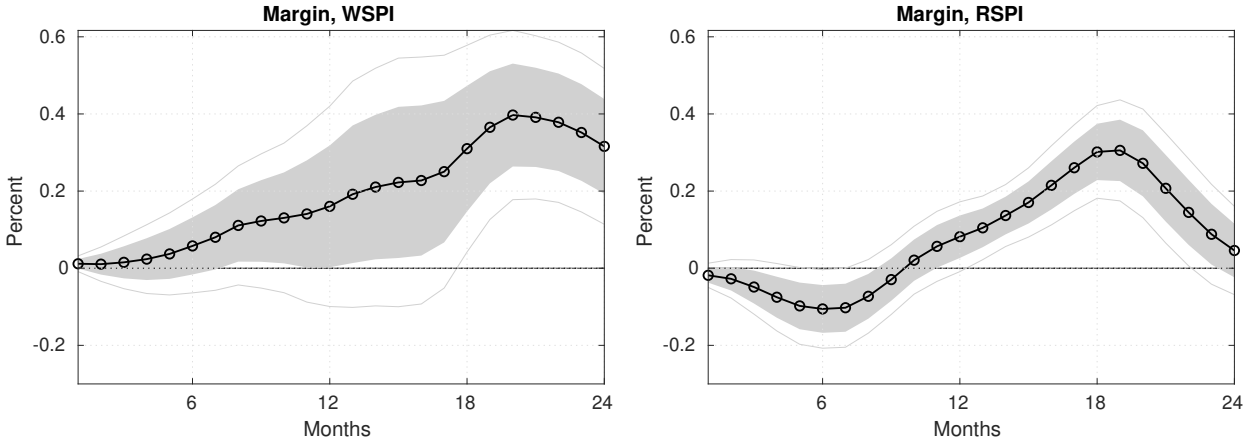
Notes: See Fig. 5.

Figure 6: Responses of inflation rates to a 10% oil price shock (increase)

Panel A: response to a 1% monetary policy shock (tightening)



Panel B: response to a 10% oil price shock (increase)



Notes: See Fig. 5.

Figure 7: Responses of margins to 10% oil price shock

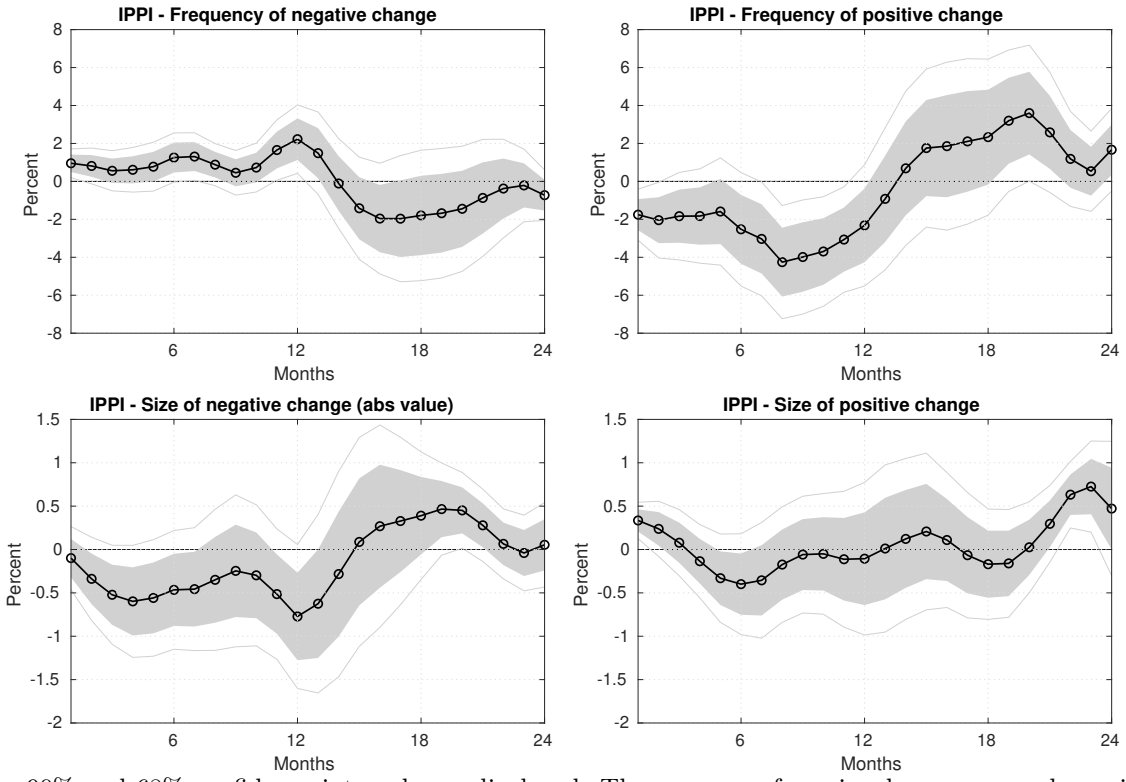
Table 1: Summary statistics of price changes, 2014-2024

	Mean	Median	Min	Max	SD
Panel A: frequency, %					
IPPI	41.55	43.00	27.00	56.00	6.74
WSPI purchase price	36.49	35.00	26.00	52.00	6.08
WSPI selling price	41.27	40.00	33.00	54.00	4.70
RSPI purchase price	20.04	19.50	10.00	34.00	6.47
RSPI selling price	22.86	22.00	12.00	42.00	6.51
CPI	29.52	28.45	21.70	42.80	5.07
Panel B: size, %					
IPPI	0.72	0.60	-7.20	8.40	2.37
WSPI purchase price	1.58	1.30	-3.70	12.30	2.12
WSPI selling price	1.26	1.00	-2.10	7.50	1.70
RSPI purchase price	1.30	1.30	-4.10	8.00	2.10
RSPI selling price	0.75	0.55	-3.30	5.80	2.21
CPI	1.03	1.22	-3.64	4.56	1.51
Panel C: interquartile range, p.p.					
IPPI	6.36	5.90	2.30	22.20	2.50
WSPI purchase price	7.45	7.25	3.10	19.10	1.93
WSPI selling price	7.67	7.60	4.20	11.00	1.24
RSPI purchase price	7.08	6.70	0.10	17.50	3.22
RSPI selling price	7.04	6.85	0.20	16.50	3.37
CPI	10.45	8.37	5.65	22.56	4.18
Panel D: markups (proxy)					
WSPI	0.38	0.37	0.32	0.44	0.03
RSPI	0.50	0.50	0.45	0.56	0.02

Notes: Summary statistics are computed using monthly data over 2014M1–2024M12 ($N = 120$ observations). The frequency of price changes is measured as the share of prices that change in each month; the size of price changes is the average non-zero monthly price change and the dispersion is the interquartile range of the distribution of price changes in each month. Markups are proxied by the log of the ratio between the selling and the purchasing prices.

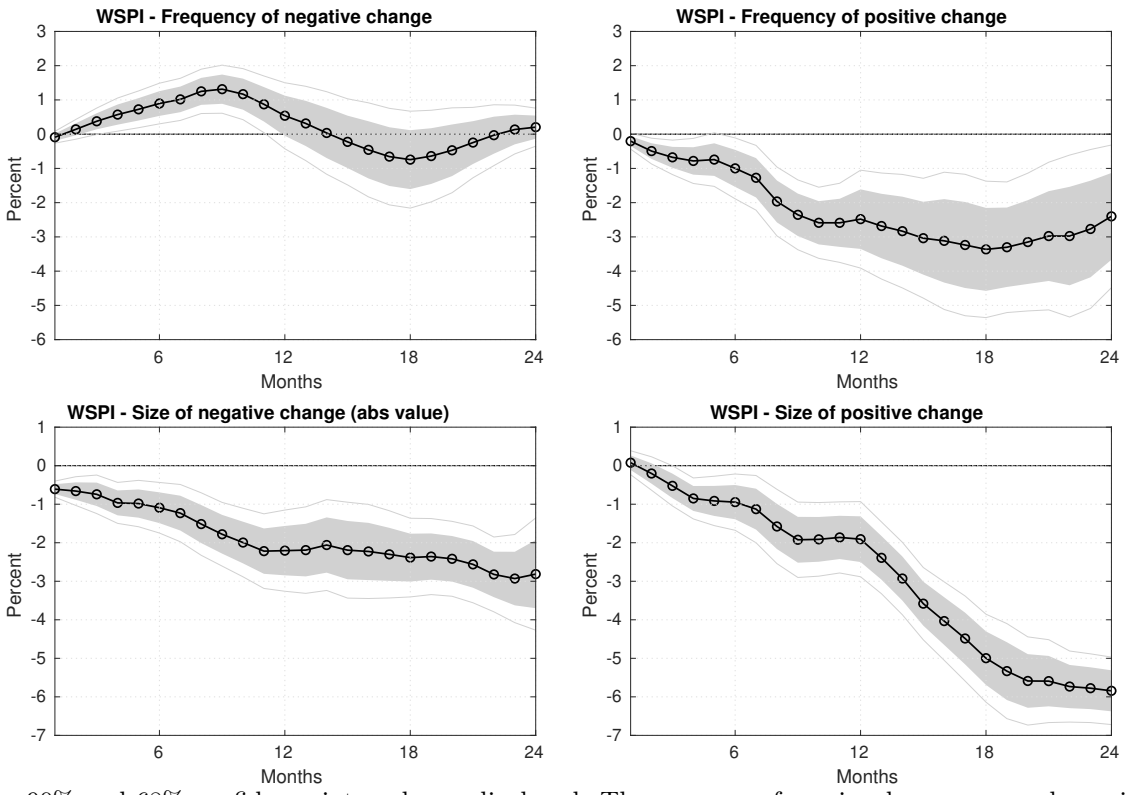
A Impulse response functions of frequency and size of price increases and price decreases

A.1 Monetary policy shock



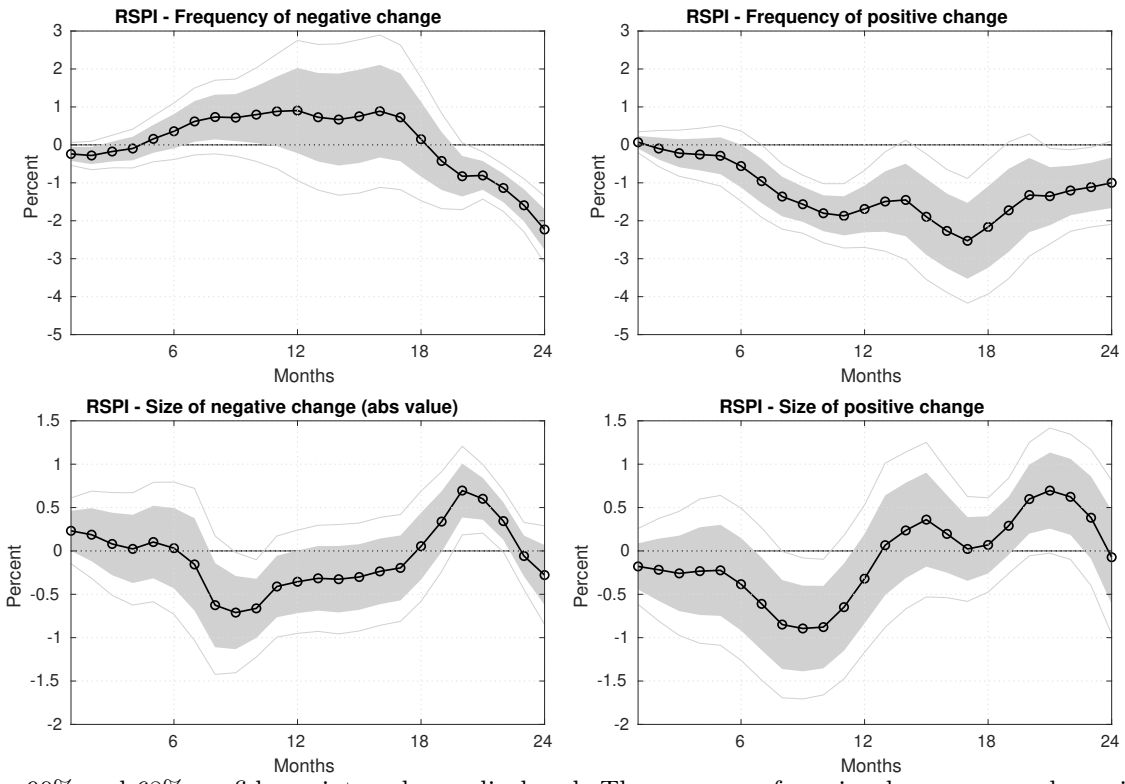
Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.1: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **manufacturing** to a 1% monetary policy shock.



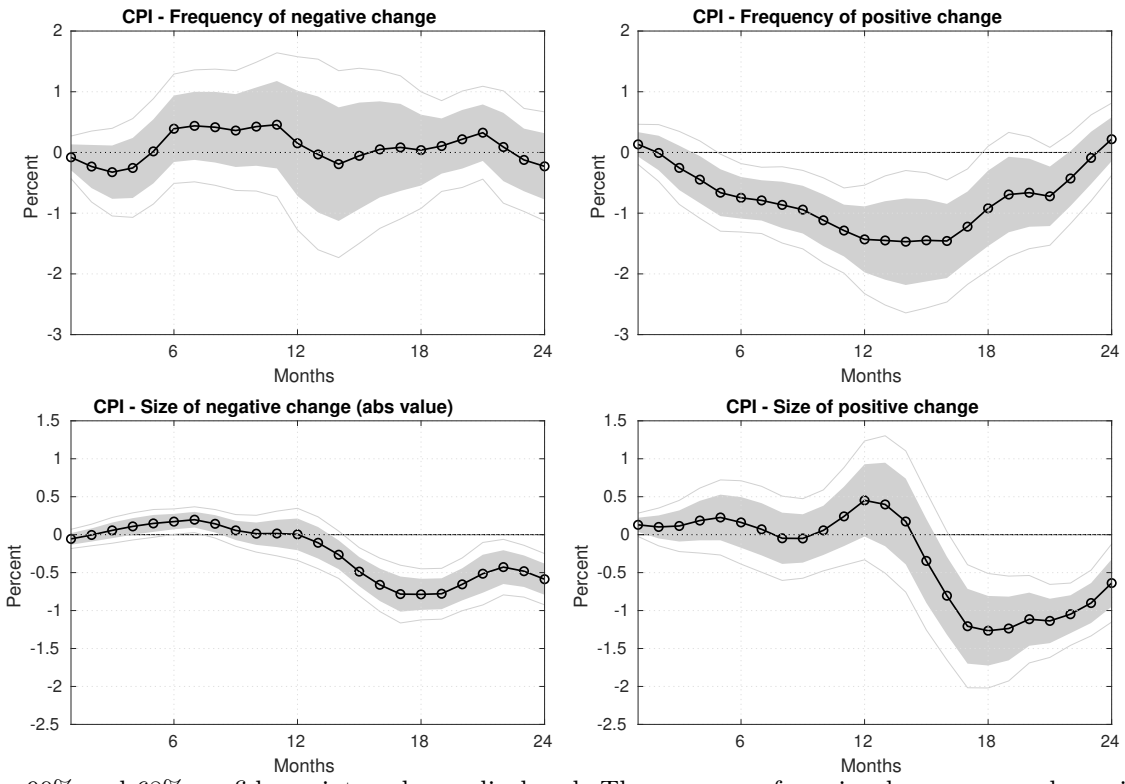
Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.2: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **wholesale** to a 1% monetary policy shock.



Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

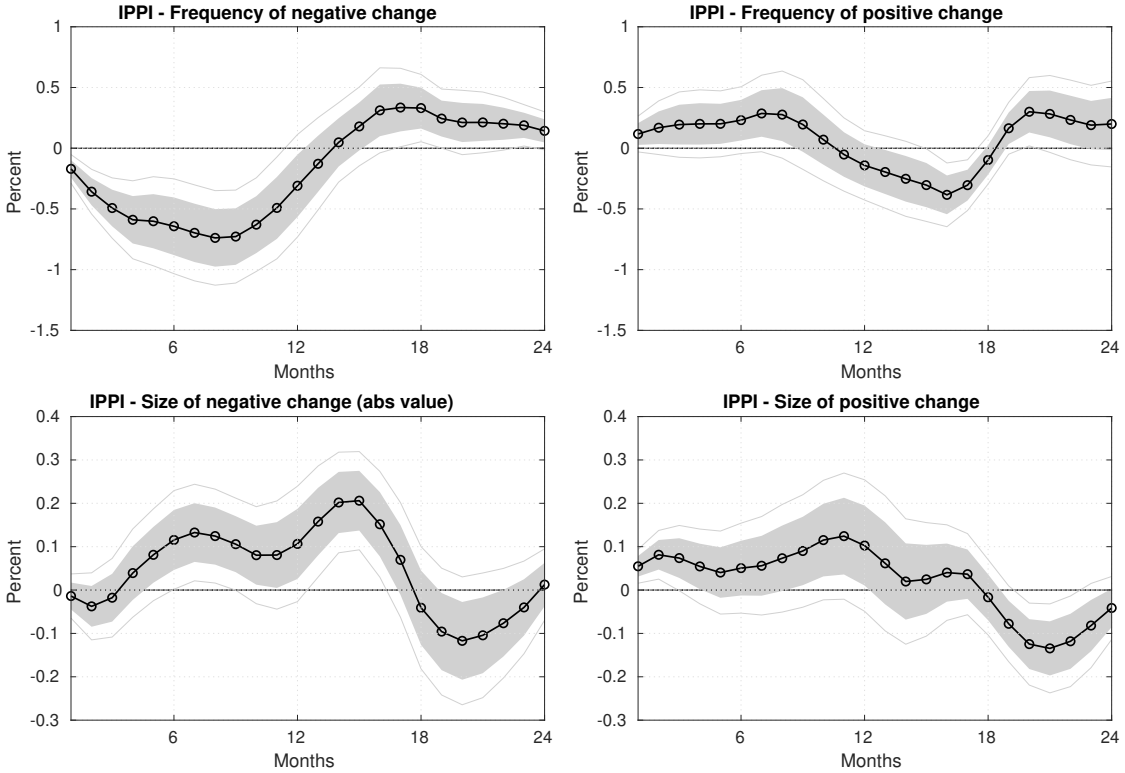
Figure A.3: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **retail** to a 1% monetary policy shock.



Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

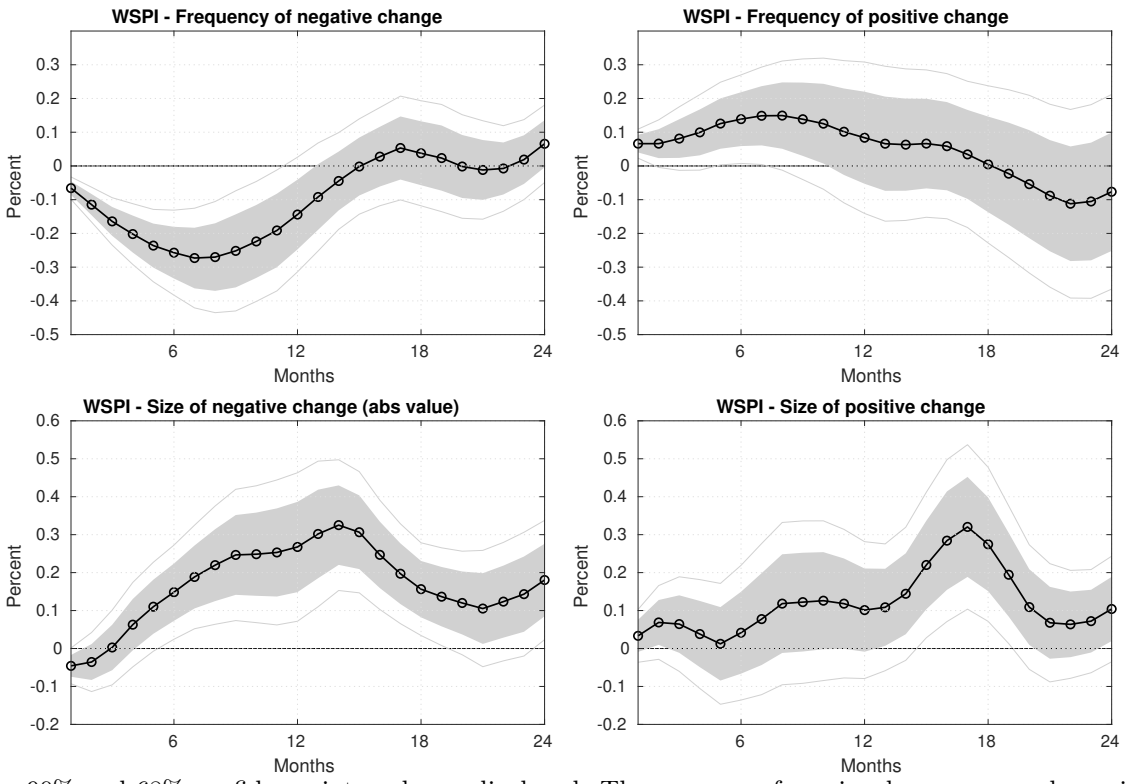
Figure A.4: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **CPI** to a 1% monetary policy shock.

A.2 Oil supply news shock



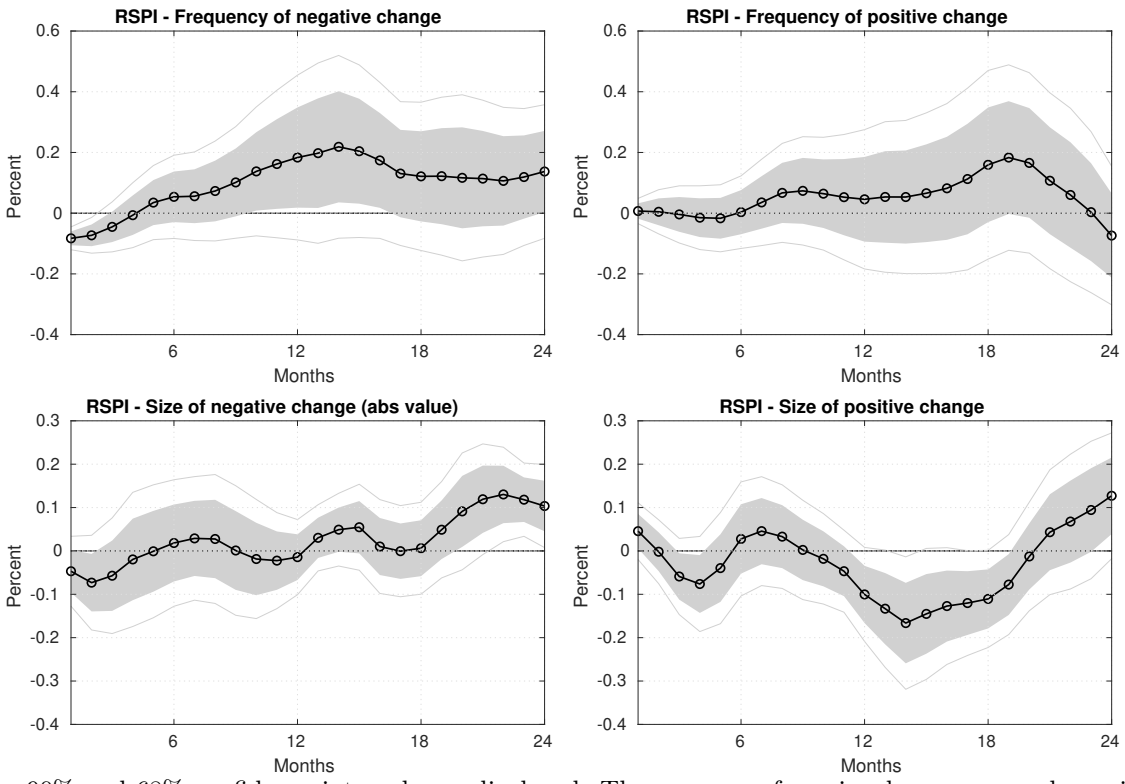
Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.5: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **manufacturing** to a 10% oil supply shock.



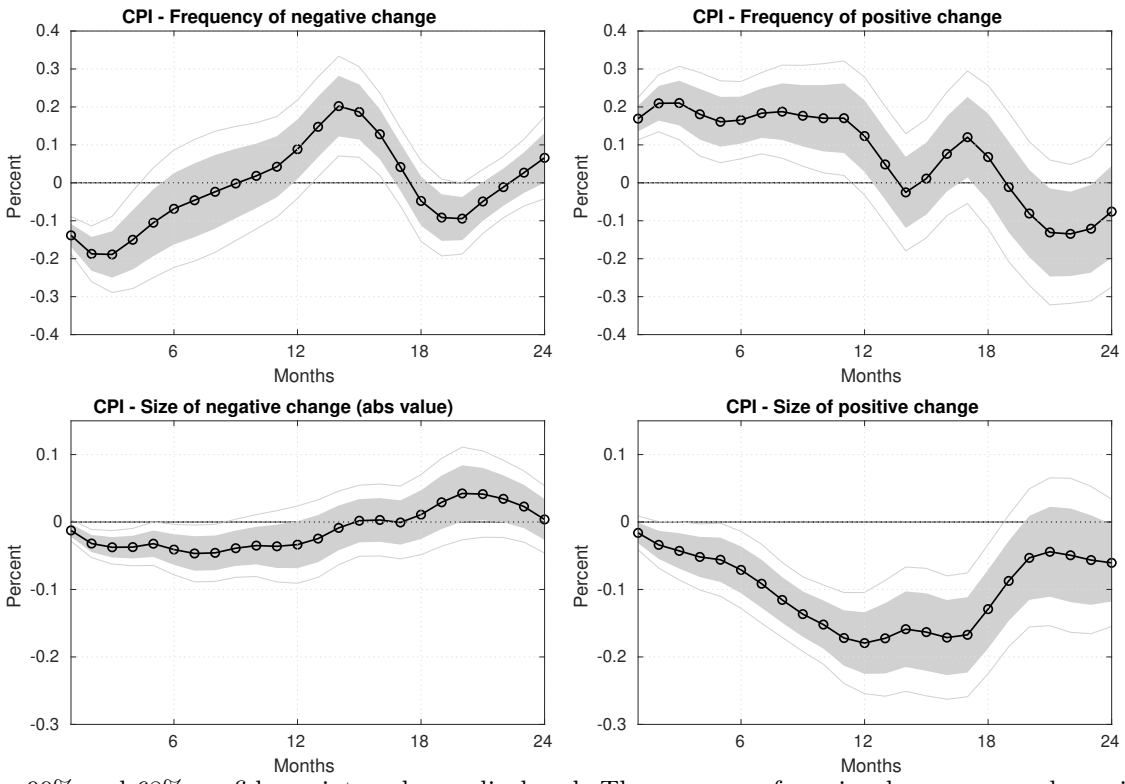
Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.6: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **wholesale** to a 10% oil supply shock.



Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.7: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **retail** to a 10% oil supply shock.



Notes: 90% and 68% confidence intervals are displayed. The responses for price decreases are shown in the first column (the size is in absolute value), and for price increases in the second column.

Figure A.8: Responses of the frequency of price changes (first row) and of the size of price changes (second row) in **CPI** to a 10% oil supply shock.

B Descriptive statistics

Table B.1: Frequency of price changes, 2014–2024

	Mean	Median	Min	Max	SD
IPPI					
IPPI (total)	41.55	43.00	27.00	56.00	6.74
IPPI (positive price changes)	23.31	22.50	11.00	43.00	7.50
IPPI (negative price changes)	18.27	17.50	7.00	36.00	6.18
WSPI					
WSPI purchase price (total)	36.49	35.00	26.00	52.00	6.08
WSPI purchase price (positive price changes)	20.56	20.00	11.00	35.00	5.28
WSPI purchase price (negative price changes)	15.89	15.00	10.00	29.00	3.68
WSPI selling price (total)	41.27	40.00	33.00	54.00	4.70
WSPI selling price (positive price changes)	22.64	22.00	16.00	37.00	4.34
WSPI selling price (negative price changes)	18.66	19.00	14.00	25.00	2.21
RSPI					
RSPI purchase price (total)	20.04	19.50	10.00	34.00	6.47
RSPI purchase price (positive price changes)	11.56	11.00	4.00	22.00	4.19
RSPI purchase price (negative price changes)	8.45	8.00	2.00	18.00	3.23
RSPI selling price (total)	22.86	22.00	12.00	42.00	6.51
RSPI selling price (positive price changes)	12.74	12.00	5.00	24.00	4.03
RSPI selling price (negative price changes)	10.08	10.00	3.00	21.00	3.67
CPI					
CPI (total)	29.52	28.45	21.70	42.80	5.07
CPI (positive price changes)	16.16	15.50	8.60	27.90	4.47
CPI (negative price changes)	13.35	12.75	7.70	23.00	3.16

Notes: See Table 1.

Table B.2: Size of price changes (absolute), 2014–2024

	Mean	Median	Min	Max	SD
IPPI					
IPPI (total)	0.72	0.60	-7.20	8.40	2.37
IPPI (positive price changes)	6.48	6.40	3.20	15.70	1.77
IPPI (negative price changes)	6.25	5.80	3.10	18.20	2.20
WSPI					
WSPI purchase price (total)	1.58	1.30	-3.70	12.30	2.12
WSPI purchase price (positive price changes)	10.83	8.75	5.20	26.40	4.82
WSPI purchase price (negative price changes)	8.80	7.90	4.30	16.80	2.85
WSPI selling price (total)	1.26	1.00	-2.10	7.50	1.70
WSPI selling price (positive price changes)	10.22	8.50	6.40	22.70	3.86
WSPI selling price (negative price changes)	8.38	7.50	5.60	14.00	2.11
RSPI					
RSPI selling price (total)	0.75	0.55	-3.30	5.80	2.21
RSPI selling price (positive price changes)	10.78	10.40	4.60	22.80	2.86
RSPI selling price (negative price changes)	9.86	9.60	5.70	18.80	2.02
RSPI purchase price (total)	1.30	1.30	-4.10	8.00	2.10
RSPI purchase price(positive price changes)	9.53	9.20	4.50	22.10	3.17
RSPI purchase price (negative price changes)	8.30	8.00	4.60	19.10	2.39
CPI					
CPI (total)	1.03	1.22	-3.64	4.56	1.51
CPI (positive price changes)	16.52	16.90	11.81	21.92	2.79
CPI (negative price changes)	14.54	14.88	10.98	18.48	1.92

Notes: See Table 1. The size is in absolute value.

Table B.3: Inter-quartile range of price changes, 2014–2024

	Mean	Median	Min	Max	SD
IPPI	6.36	5.90	2.30	22.20	2.50
WSPI purchase price	7.45	7.25	3.10	19.10	1.93
WSPI selling price	7.67	7.60	4.20	11.00	1.24
RSPI purchase price	7.08	6.70	0.10	17.50	3.22
RSPI selling price	7.04	6.85	0.20	16.50	3.37
CPI	10.45	8.37	5.65	22.56	4.18

Notes: See Table 1.