INTERNATIONAL MONETARY FUND

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## Evidence from Sectoral Data in the U.S.

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WP/23/233



**2023**
NOV

WORKING PAPER

 WP/23/233

**IMF Working Paper**
Western Hemisphere Department

# The Pass-through of Wages to Consumer Prices in the COVID-19 Pandemic: Evidence from Sectoral Data in the U.S.

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Authorized for distribution by Nigel Chalk
November 2023



**ABSTRACT:** We study the pass-through of labor costs to prices using a novel data-set that links industry-level wages to sectoral consumer prices through input-output tables. Pass-through increased during the COVID-19 pandemic recovery, temporarily in goods and persistently in services. Our analysis suggests that the elevated pass-through contributed at least 0.8 percentage points to goods inflation in 2021 and 0.7 percentage points and 0.5 percentage points to services inflation in 2021 and 2022, respectively. We find that the increase in pass-through reflects elevated demand in goods sectors and firms' difficulty in absorbing high wage growth in services sectors. The analysis suggests it will take a reduction in wage growth to bring PCE inflation back to target. Fiscal and monetary policies that help to re-balance the labor markets can facilitate this process.

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|---|---|
| JEL Classification Numbers: | E24, E31 |
| Keywords: | Inflation dynamics; pass-through |
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* We thank John Bluedorn, Nigel Chalk, Jean-Marc Fournier, Gaston Gelos, Andrew Hodge, Lucy Liu, Tannous Kass-Hanna, Koshy Mathai, and Anke Weber for helpful comments and discussion. All remaining errors are our own.

# 1 Introduction

Despite remaining low for three decades prior to the COVID-19 pandemic, consumer price inflation and median wage growth in the U.S. surged from 2.0 and 3.7 percent to 9.1 and 6.7 percent in 2022, respectively.[1] Their swift and persistent increase has led many economists to revisit existing economic models and raised concerns of a structural shift in the economy. Developments in labor markets became extremely important as inflation pressures in 2022 shifted from goods to more labor-intensive services sectors. Understanding the drivers behind these surges and the potentially different relationship between wages and prices across sectors are key policy questions for taming inflation.

In this paper, we revisit the relationship between wages and prices and focus on one direction of this relationship: the pass-through from wage inflation to price inflation. Theoretically, wage increases may be expected to translate to price increases through either a cost-push channel, where firms increase prices in response to higher input costs, or through a demand-driven channel, where increases in income drive up demand and prices. However, empirically, there has been limited evidence of significant pass-through in the U.S. (Bobeica et al. 2021, Peneva and Rudd 2017). The decline in recent decades has been attributed to structural factors.[2]

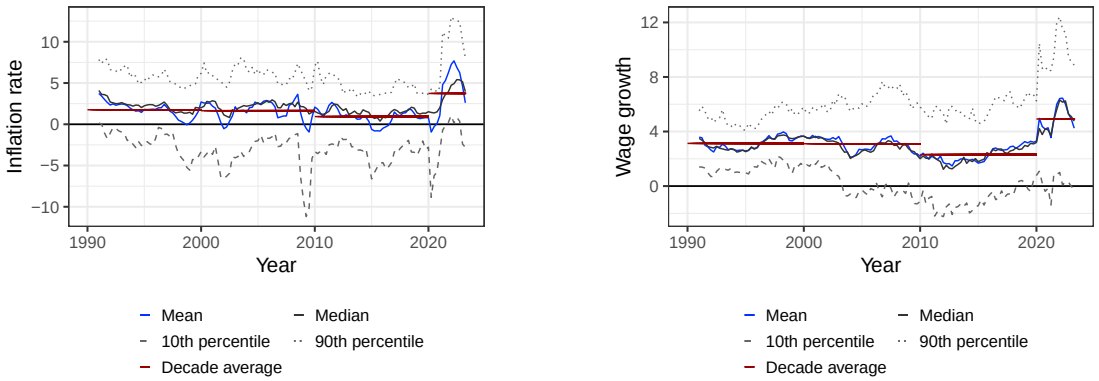
The limited pass-through may also reflect the empirical fact that both wage growth and inflation have been low for decades and thus provide little variation for estimating pass-through.[3] In contrast to the aggregate trends, wage growth and inflation have not been uniformly low, nor stable, nor co-move across industries and sectors in the economy (Figure 1). This paper exploits this variation to

[1] Median wage growth is from the Atlanta Fed Wage Growth Tracker.

[2] Structural factors that have been studied include increased market concentration (Heise et al. 2021), globalization (see Obstfeld (2020) for a review), and better anchored inflation expectations (Bobeica et al. 2021, Peneva and Rudd 2017).

[3] See Appendix B.1.

study the extent to which growth in wages of upstream *input* industries translates to growth in prices of *final goods*, both historically and during the COVID-19 pandemic recovery. To do this, we link consumer prices of goods from the Personal Consumption Expenditure (PCE) price index with the effective wage in producing that good.




(a) Price inflation (b) Wage inflation

Figure 1: Sectoral inflation and wage growth between 1990-2023

*Note:* The figures plot the mean, median, 10th percentile, 90th percentile, and decade average of price growth across PCE sectors (Panel a) and wage growth across CES industries (Panel b). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

The empirical challenge with our approach is that prices of consumer goods, which are the final products of multiple production processes across multiple industries, do not readily match to the costs of labor inputs, which are recorded at the industry level. This is in contrast to producer prices, which are defined at the industry level.[4] To link industry labor costs to consumer prices, we use input-output matrices to construct the effective labor cost embedded in the production

[4]For some sectors, the mapping from industry-level wages to consumer prices is straightforward. For instance, the wage data in the Current Employment Statistics (CES) for "food services and drinking places" can be mapped to the PCE price data for "purchased meals and beverages." However, for other sectors, this mapping is not straightforward. For instance, wage data in the CES for both "motor vehicle manufacturing" and "motor vehicle body and trailer manufacturing" can be potentially mapped to PCE price data for "motor vehicle parts and accessories." As another example, wage data is not directly available for the consumption good "therapeutic appliances and equipment." Rather, wage data is available for industries such as "electronic instruments manufacturing," "medical equipment supplies and manufacturing," and "offices of other health practitioners," whose outputs are used in the production of "therapeutic appliances and equipment."

process of a final good.

We construct a quarterly panel of 68 output sectors in the PCE price index between 2010 and 2023. We estimate the pass-through from wage inflation to price inflation by examining the response of final goods prices to wage growth. We compare this response during the historical period prior to the COVID-19 pandemic with the response during the COVID-19 pandemic recovery to study how and why pass-through may have changed.

To begin, we present estimates of the historical pass-through using a local projection specification to estimate the impulse response of price inflation to wage inflation. We find substantial variation in pass-through across sectors. Pass-through is statistically indistinguishable from zero in goods sectors and positive in services sectors, peaking at 27.9 percent and persisting for six quarters. While more labor-intensive firms do exhibit higher pass-through, we find that pass-through is far from 1 even in sectors that completely rely on labor, indicating the importance of other factors in determining the extent of pass-through.

The challenge in empirically estimating pass-through is potential endogeneity, as current inflation can also feed into wage growth. Without exogenous shocks or instruments for wage growth, our estimates cannot be interpreted causally. We argue that this reverse causality is limited in our analysis. First, we analyze wage and inflation developments at a quarterly frequency, to exploit the fact that current inflation takes more than a quarter to be reflected into wages. Second, we estimate the impulse response of wages to inflation at the metropolitan-level and do not find evidence of a strong response of wages to prices within a 12-month horizon. Finally, we estimate an instrumental variable regression, using job-to-job transition rates as an instrument for wage growth in services sectors, and find that the estimates corroborate the positive pass-through from our impulse response estimates.

We next turn to the question of whether the pass-through from wage growth

to price growth has remained stable, especially in the COVID-19 pandemic recovery. To examine pass-through prior to the COVID-19 pandemic, we use 5-year rolling windows and estimate the largest impulse response of price inflation to wage inflation over an eight-quarter horizon. In the years leading to the COVID-19 pandemic since 2014, pass-through has been stable around 15 percent then slightly declining in 2018-19 in goods sectors and declining in services sectors to less than 20 percent by 2019. While pass-through has not remained constant in the decade prior to the COVID-19 pandemic, it has not exhibited increasing trends. To examine pass-through during the COVID-19 pandemic recovery, we test whether the contemporaneous impulse response is significantly larger in 2021-2023 compared to 2010-2020. We find that this is indeed the case, both for goods and services, but also that goods and services sectors experienced different trajectories. Pass-though in goods sectors was initially elevated, but moderated later in the recovery period. Pass-through in services sectors increased by about 10 percent and has remained elevated. The estimated magnitude implies that higher pass-through in the COVID-19 pandemic recovery increased goods inflation by 0.8-1.0 percentage points by the third quarter of 2021 and services inflation by 0.7-0.8 percentage points in 2021 and by 0.5 percentage points in 2022.

The elevated pass-through in the COVID-19 pandemic recovery raises a question for policymakers going forward: does this indicate a structural change or does this reflect concurrent economic developments? We study three economic developments that have characterized the COVID-19 pandemic recovery: high wage growth, supply chain disruptions, and excess demand.

First, we estimate the contemporaneous impulse response and test whether pass-through is higher in periods of high wage growth. We find that pass-through tends to increase in services sectors during periods of high wage growth. We argue that a large share of the increase in pass-through in services sectors during the COVID-19 pandemic recovery is due to higher wage growth. When examining

the pre-COVID period, the magnitude of the increase in pass-through in services sectors is comparable to the increase in pass-through in the COVID-19 pandemic recovery. Further, when controlling for high wage growth, pass-through in the COVID-19 pandemic recovery is no longer elevated.

Second, we analyze whether supply-side disruptions, which we measure as import price and input price growth, have created an amplification effect, where concurrent increases in import and input prices with wages reduced the ability of firms to substitute between factors of production, leading to increased pass-through in the COVID-19 pandemic recovery. While supply-side disruptions have contributed directly to inflation, we do not find evidence that these disruptions have led to an amplification effect.

Third, we find evidence that excess demand, which we measure as the deviation of sectoral personal consumption expenditures from its trend, provided firms with more pricing power and increased pass-through in goods sectors. Excess demand led to higher pass-through in goods sectors during the second half of 2020 into 2021. When controlling for excess demand, pass-through in the COVID-19 pandemic recovery is no longer elevated in goods sectors.

Taken together, we find stronger evidence that the higher pass-through during the COVID-19 pandemic recovery reflects concurrent economic developments instead of a structural break. Part of the increase in inflation during the COVID-19 pandemic recovery has been driven by economic developments that are expected to normalize (strong demand in goods sectors). However, we find a significant increase in pass-through in services sectors during periods of high wage growth, indicating the importance of fiscal and monetary policy in re-balancing labor markets to return inflation to target.

Our work is related to studies using disaggregated data series to study input costs and prices (Amiti et al. 2019, Bobeica et al. 2021, Heise et al. 2021). Of particular interest are Heise et al. (2021) who document declining pass-through from

wage inflation to producer price inflation in manufacturing prior to the COVID-19 pandemic and attribute this decline to rising import competition and market concentration. Like Heise et al. (2021), we find a high pass-through in services and low pass-through in goods. Our findings complement their analysis by considering not only pass-through to *producer* prices but also pass-through to *final goods* prices.

This paper also contributes to recent work seeking to understand inflation drivers in the COVID-19 pandemic recovery. These have included compositional shifts in consumption, supply chain pressures, and labor shortages (Amiti et al. 2022, Crump et al. 2022, di Giovanni et al. 2022, International Monetary Fund 2022, LaBelle and Santacreu 2022). Our paper contributes to this discussion by examining the wage-to-price channel specifically. Our approach follows closely that of Amiti et al. (2022), who use sectoral *producer prices* and provide cross-sectional evidence of higher pass-through in wages to prices in goods sectors during the first three quarters of 2021, attributing this to the concurrence of wage shocks with intermediate goods price shocks.

The remainder of the paper is organized as follows. Section 2 describes the data used in the empirical analysis. Section 3 summarizes the methodology used to link labor costs to consumer prices. Section 4 presents the historical estimates of pass-through. Section 5 examines whether pass-through is different in the COVID-19 pandemic recovery and Section 6 explores potential explanations for these differences. Section 7 concludes.

# 2 Data sources

In this section and throughout the paper, "industries" refers to input, or producing, industries and "sectors" refers to output, or final goods, sectors. Details on other data sources used outside of the main specifications are available in Ap-

pendix A.

## 2.1 Industry-level data

Data on labor costs, productivity, input prices, and import prices were collected for NAICS industries. Data was collected at the two-, three-, and four-digit NAICS industry level, where the level was chosen according to the most granular level available that matched the level used in the input-output matrices.[5]

To measure labor costs, we use seasonally adjusted, monthly wages from the Current Employment Statistics (CES) database (Bureau of Labor Statistics 1988-2023*b*).[6] We collapse wages to the quarterly level by taking the average monthly wage within each quarter. To measure productivity, we use annual total factor productivity from the Integrated Industry-Level Production Account (Bureau of Economic Analysis 1987-2020), the Annual Labor Productivity and Costs by Detailed Industry (Bureau of Labor Statistics 1987-2023*a*), and the Utilization-Adjusted Quarterly-TFP series for the U.S. Business Sector (Fernald 2014).[7] To measure production costs other than direct wage costs, we use intermediate goods prices (which we refer to as input prices) from the monthly Producer Price Index (Bureau of Labor Statistics 1981-2023*c*).[8]. To measure imported production costs and price competition from foreign goods, we use import prices from the monthly Import/Export Price Index (MXP) (Bureau of Labor Statistics 2005-2022).[9]

[5]The majority of input industries in the input-output matrices are defined at the four-digit level, with only two defined at the two-digit level (construction and wholesale trade).

[6]Specifically, average hourly earnings of production and nonsupervisory employees.

[7]Missing data in the Annual Labor Productivity and Costs by Detailed Industry was first supplemented by data from the Integrated Industry-Level Production Account, then by data from the Utilization-Adjusted Quarterly-TFP series. The total factor productivity index (2012 = 100) series was used.

[8]The input price for an industry $i$ is a weighted average of the producer prices of all industries (other than industry $i$) that provide input to industry $i$, where the weights are the cost shares from the 2012 input-output table from the BEA (Bureau of Economic Analysis 2012). While prices of inputs may reflect labor costs in the production process, the exclusion of industry $i$ excludes the direct labor cost to industry $i$.

[9]Import prices by definition do not include domestic labor costs.

## 2.2 Sector-level data

Data on consumer prices were collected at the sector level. We use the seasonally-adjusted, monthly Personal Consumption Expenditure (PCE) price index (Bureau of Economic Analysis 1959-2023). We collapse prices to the quarterly level by taking the average monthly price index within each quarter. We measure consumer prices using the PCE price index for two reasons. One, the PCE price index is the main index used by the Federal Reserve to assess inflation developments. This is especially important for drawing the most relevant policy conclusions, as during the COVID-19 pandemic recovery a large divergence between the consumer price index (CPI) and the PCE price index developed, due to different weights across the baskets on certain components that experienced volatile prices. Two, the PCE price index uses the same sectoral classification of final goods as those used in the input-output matrices and thus allows us to link price developments with more precision.

# 3 Sectoral wages

## 3.1 Constructing sectoral wages

We use input-output matrices of real final demand (Bureau of Labor Statistics 1997-2020) to link input industries to output sectors, and thus link labor costs to consumer prices. The matrices detail the composition of the input of 75 output sectors across 172 input industries, such that each cell represents the volume purchased from each input industry in the output of each output sector.[10] Input

[10]In the matrices provided by the BLS, input industries are referred to as "commodity and industry sectors" and final goods sectors are referred to as "final demand types." The raw matrices contain 205 commodity and industry sectors and 153 final demand types. For commodity and industry sectors, we drop sectors where wage data is not available (the majority of industries include those related to agriculture and forestry and the public sector). For final demand types, we drop those related to margin reallocations, valuation adjustments and other key components of gross domestic product, such as fixed investment. Thus, only 75 types relate to consumer goods.

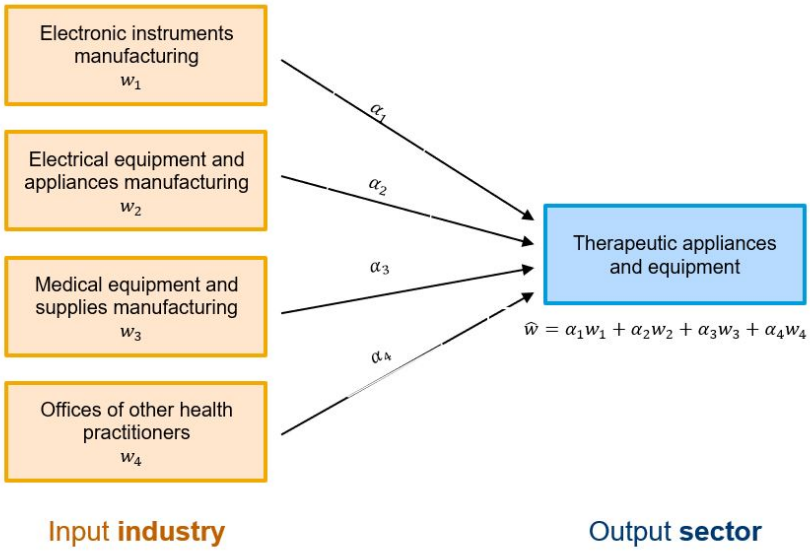



Figure 2: Constructing sectoral wages from industry wage data

industries consist of both goods (such as "apparel, leather and allied product manufacturing") and services (such as "wireless telecommunication carriers"). Similarly, output sectors consist of both goods (such as "women's and girls' clothing") and services (such as "telecommunication services"). The matrices are available yearly from 1997 through 2020. For years prior to 1997 (after 2020), we assume that the input-output structure is the same as in 1997 (as in 2020).

We link labor costs to consumer prices in three steps. We use the same procedure to link other industry-level data (total factor productivity, labor shares, import prices, and input prices).

First, we calculate the labor cost for each input industry. The CES labor cost data use the NAICS codes, which are matched to the input industries in the input-output tables.[11] We make the simplifying assumption that the goods and services used as inputs in the production of each final good are produced only by its primary production industry.[12]

[11] In cases where multiple NAICS codes matched to a single input industry, the labor cost is the average wage weighted by employment. In cases where a single NAICS code matched to multiple input industries, the same labor cost is assigned to each industry.

[12] In other words, we ignore the fact that goods and services can be produced by other industries

Second, we calculate the effective labor cost for each output sector. This is equal to the average labor cost across an output sector's input industries, where each industry is weighted by its value in the input-output table (Figure 2). We keep observations where wage, import price, and input price data for all input industries are available.[13]

Third, we link each output sector to consumer prices in the PCE price index. This results in a one-to-one matching, as the output sectors use the same classification as the PCE components.

The constructed effective wages encompass 68 output sectors between the first quarter of 1990 and the first quarter of 2023.[14] In the main specification that includes controls for total factor productivity, import prices, and input prices, the data begins in 2010.[15] 31 of these sectors are goods and 37 of these sectors are services.

## 3.2 Trends in wage growth and inflation

While four-quarter wage growth averaged 3.1 percent between 1990 and 2009, wage growth declined to 2.2 percent between 2010 and 2019 and increased markedly to 4.9 percent since 2020. In 2022, wage growth averaged 6.3 percent. On average, wage growth has been higher in service sectors compared to goods sectors but wage growth increased in both during the COVID-19 pandemic recovery (Figure 3). In general, sectors with the highest average wage growth in 1990-2020 were

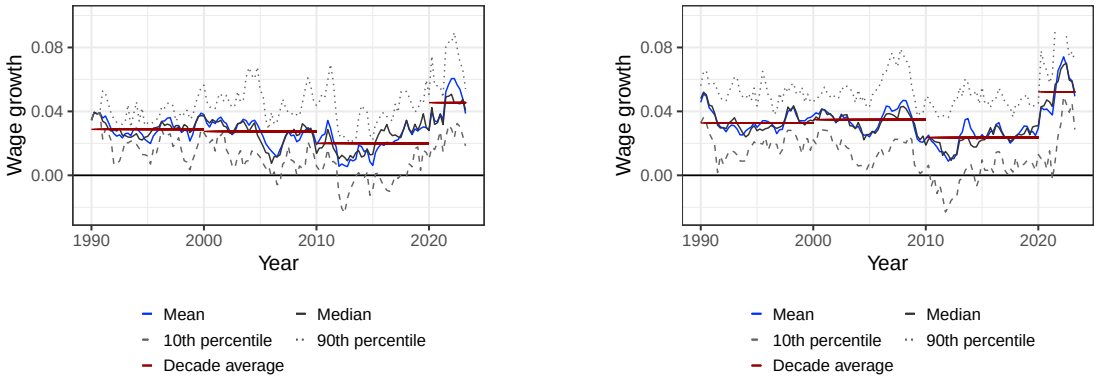
as secondary output, so that input goods and services and input industries are equivalent. For example, goods and services produced by the "Food services and drinking places" industry are produced only by this industry, even if other industries (such as hospitals and accommodation) may also produce these goods and services.

[13]Wage data is missing for 4 output sectors: "net purchases of used motor vehicles," "food produced and consumed on farms," "net expenditures abroad by U.S. residents," and "imputed rental of owner-occupied nonfarm housing." Input prices and import prices are missing for 3 output sectors: "educational books," "rental of tenant-occupied nonfarm housing," and "rental value of farm dwellings."

[14]Data for four sectors are unavailable until the first quarter of 2003.

[15]Data is available for some sectors between 2007-2009, but we exclude these years as only 1 goods sector had data available.

services sectors, but this was not necessarily true during the COVID-19 pandemic recovery as many goods sectors experienced high wage growth as well.[16]




(a) Goods sectors (b) Services sectors

Figure 3: Wage growth in output sectors between 1990-2023

*Note:* The figures plot the mean, median, 10th percentile, 90th percentile and decade average of wage growth across goods sectors (Panel a) and services sectors (Panel b). Wage growth is the four-quarter log change in wages and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

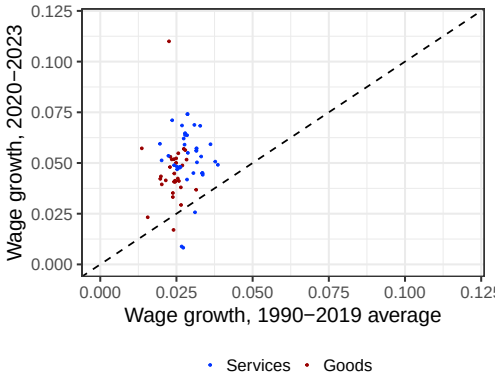
In fact, nearly all sectors experienced higher wage growth in the COVID-19 pandemic recovery compared to the average in the prior three decades (Panel a of Figure 4).[17] While this was mostly the case for inflation as well, some goods and services sectors experienced lower inflation in the COVID-19 pandemic recovery, largely in the sectors of education, healthcare, insurance, telecommunication and utilities (Panel c of Figure 4).[18] Looking at wage and price growth at the sectoral level reveals a contrast to the trends at the aggregate level. In addition to higher variation in *sectoral* wage and inflation growth prior to the COVID-19 pandemic,

[16]For example, telephone and fascimile equipment is a goods sector and had the highest wage growth in 2021-2023; see Appendix B.1.

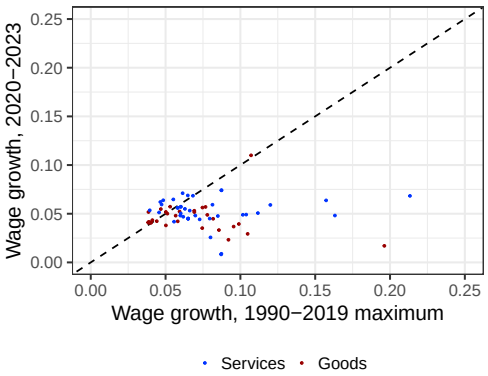
[17]4 sectors experienced lower wage growth in the COVID-19 pandemic recovery: "Pharmaceutical and other medical products," "Audio-video, photographic, and information processing equipment services," "Telecommunication services," and "Internet access."

[18]20 sectors experienced lower inflation in the COVID-19 pandemic recovery; of these, 16 were in the services sectors. The goods sectors include "Educational books," "Pharmaceutical and other medical products," "Therapeutic appliances and equipment," and "Telephone and facsimile equipment." The services sectors include "Commercial and vocational schools," "Higher education," "Nursery, elementary, and secondary schools," "Dental services," "Hospitals," "Nursing homes," "Net health insurance," "Life insurance," "Net household insurance," "Net motor vehicle and other transportation insurance," "Ground transportation," "Paramedical services," "Physician services," "Professional and other services," "Telecommunication services," "Water supply and sanitation."

while *aggregate* wage growth and inflation have surged to levels far exceeding that of the prior three decades, *sectoral* growth rates during the COVID-19 pandemic recovery are not outliers (Panels b and d of Figure 4). Our study exploits this rich variation in sectoral wage and price inflation both prior to and during the COVID-19 pandemic recovery.

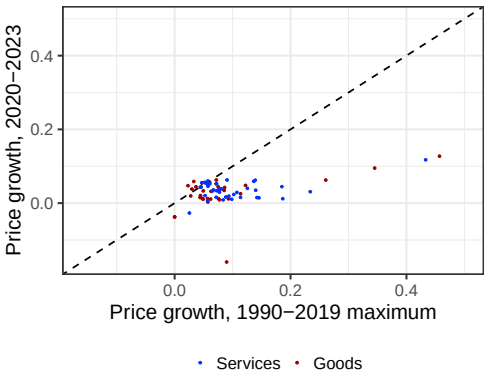



(a) Wage growth, 1990-2019 (average) vs. 2020-2023 (average)




(b) Wage growth, 1990-2019 (max) vs. 2020-2023 (average)


(c) Inflation, 1990-2019 (average) vs. 2020-2023 (average)



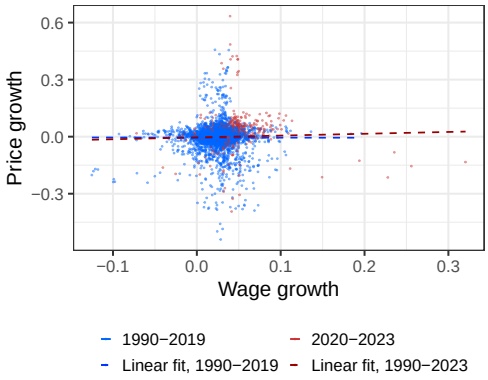

(d) Inflation, 1990-2019 (max) vs. 2020-2023 (average)

Figure 4: Wage growth and inflation in output sectors before and after the COVID-19 pandemic

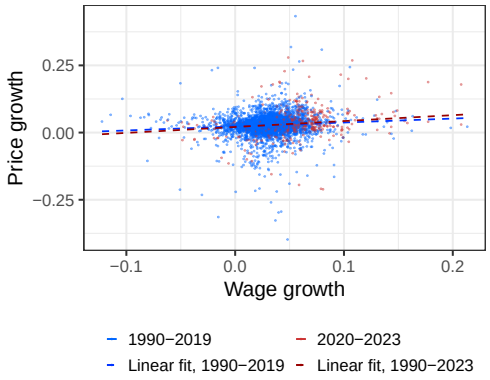
*Note:* The figures plot the growth in wages (Panels a and b) and prices (Panels c and d). The horizontal axis is either the average growth (Panels a and c) or maximum growth (Panels b and d) between 1990-2019. The vertical axis is the average growth between 2020-2023. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

Prior to the COVID-19 pandemic recovery, the correlation between wage growth and inflation was slightly negative for goods sectors, at -0.004, and positive for services sectors, at 0.147 (Panels a and b Figure 5). In the COVID-19 pan-

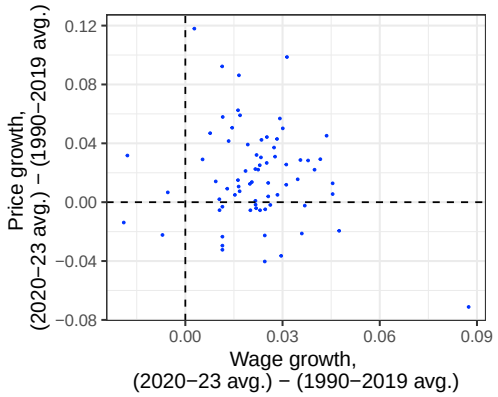
demic recovery, this correlation increased for both goods, to 0.096, and services, to 0.220. While both wage growth and inflation were higher in 2020-2023 compared to 1990-2019 for most sectors, sectors with a greater change in wage growth in the COVID-19 pandemic recovery did not generally have a greater change in price growth in the COVID-19 pandemic recovery (Panel c of Figure 5). These raw correlations suggest that wage increases translate into price increases, and that this tendency increased during the COVID-19 pandemic recovery, but also that other variables may explain this increased tendency. We test this hypothesis more formally in the remainder of this paper.




(a) Wage vs. price growth, goods sectors




(b) Wage vs. price growth, services sectors




(c) Change in wage vs. price growth between 1990-2019 and 2020-2023

Figure 5: Correlation of wage growth and inflation in output sectors

*Note:* Panels a and b plot the growth in wages (horizontal axis) and prices (vertical axis) for goods sectors (Panel a) and services sectors (Panel b). Panel c plots the difference in wage growth (horizontal axis) and price growth (vertical axis) between the 1990-2019 average and the 2020-2023 average. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

# 4 Pass-through from labor costs to prices

## 4.1 Local projections

We begin by presenting estimates of the pass-through from wage inflation to price inflation between 2010-2023. We use a local projection specification to estimate the impulse response of price inflation to wage inflation. The specification largely follows Heise et al. (2021) but also includes import price and input price inflation as controls. Specifically, we estimate Equation 1 for each quarter $h = 0, \ldots, 12$:

$$\begin{aligned}\Delta \ln(p_{i,t+h}) = \alpha + \beta_h \Delta \ln(w_{it}) + \sum_{j=1}^{8} \delta_j \Delta \ln(p_{i,t-j}) + \sum_{j=1}^{8} \zeta_j \Delta \ln(w_{i,t-j}) \\ + \gamma \mathbf{X}_{it} + \xi_i + \rho_t + \varepsilon_{it}\end{aligned} \tag{1}$$

where for sector $i$ and quarter $t$, $\Delta \ln(p_{it})$ is the four-quarter log change in price, $\Delta \ln(w_{it})$ is the four-quarter log change in the effective wage, $\mathbf{X}_{it}$ is a vector of controls (including four-quarter log changes in total factor productivity, import prices, and input prices),[19] $\xi_i$ is a sector fixed effect, and $\rho_t$ is a quarter fixed effect. The coefficient of interest, $\beta_h$, measures the pass-through of growth in wages in quarter $t$ to growth in prices in quarter $t+h$. We weight the regression by a sector's share in the total nominal PCE[20] and use Driscoll-Kraay standard errors with a lag of two quarters to account for cross-sectional and time-series correlation. We estimate Equation 1 separately for goods and services sectors.[21]

There is significant heterogeneity in pass-through between goods and services sectors (Figure 6). In goods sectors, pass-through is largely statistically indistin-

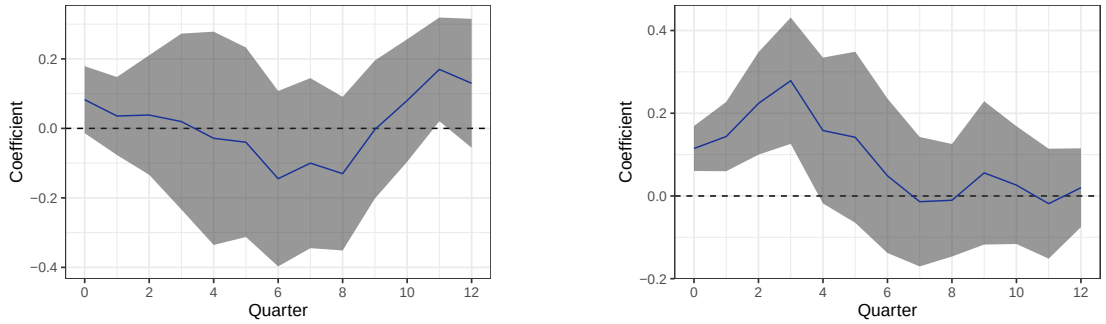
[19] Import prices are only available for goods sectors. Thus, the goods sectors regressions include both import prices and input prices as controls while the services sectors regressions include only input prices as control.

[20] The weights are the shares from December 2019.

[21] For all our analysis, given the dual role of housing as both an asset and provider of housing services and thus may have different pricing dynamics, we show that all of our results are the same if restricting to non-shelter services only (Appendix B.3).

guishable from zero. The pass-through coefficient is 8.3 percent ($p = 0.164$) in the same quarter and remains positive and declines over the next three quarters. Pass-through in services sectors, on the other hand, is significantly positive. Pass-through increases from 11.5 percent ($p = 0.001$) in the same quarter and peaks at 27.9 percent ($p = 0.004$) in the third quarter.

While including input prices and import prices as controls curtails the sample period, excluding these controls leads to spuriously negative pass-through in goods sectors.[22] This negative pass-through is likely confounded with the concurrent disinflation in goods and general upward trend in wages in the "Great Moderation" period prior to the COVID-19 pandemic.




(a) Goods sectors

(b) Services sectors

Figure 6: Impulse responses of price inflation to wage inflation

*Note:* The figures plot the estimated pass-through of wage growth to price growth at different quarterly horizons. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

## 4.2 Endogeneity and causality

A key question is whether the estimated pass-through can be interpreted as a causal relationship, as current inflation can also feed into wage growth. Without exogenous shocks or instruments for wage growth, the coefficient $\beta_h$ in Equation

[22] See Appendix B.2. The negative estimate in goods sectors nor the positive estimate in services sectors is due to choice of the sample period.

1 does not establish a causal relationship. In this section, we discuss the interpretation of our estimates in the context of causality. Appendix B.5 presents the results in this section.

Empirically, wages have tended to be stickier than prices, making it unlikely that wages will adjust to price growth at short time horizons.[23] Bernanke and Blanchard (2023) make a similar assumption that wages respond to other variables with a lag of one quarter to identify their structural VAR model. We test this empirically by estimating the impulse response of wages to inflation at the metropolitan-level and do not find that wages respond significantly to inflation at short time horizons (12 months or less).[24]

We also estimate an instrumental variable regression using job-to-job transition rates to isolate the inflationary component of wage growth that comes from competition among employers. As in Karahan et al. (2017) and Moscarini and Postel-Vinay (2017), we find that job-to-job transition rates predict wage growth well, but only in services sectors.[25] The instrumental variable estimate of pass-through (33.2 percent, $p = 0.029$) corroborates the positive pass-through from our local projection estimates.

## 4.3 Sectoral labor shares

In a basic theoretical framework of profit maximization, firms that use more labor as inputs will adjust their prices more in response to an increase in labor costs, since these firms experience a higher increase in input costs for a given wage

[23] See Barattieri et al. (2014) for recent evidence. Wage contracts are typically negotiated at annual frequencies or more. For job switchers, wage contracts are adjusted immediately but this encompasses a small share of employed workers in each quarter (less than 7 percent before 2020).

[24] We estimate the impulse response of *aggregate* wages to *aggregate* inflation at the metropolitan area level to estimate the extent to which wages adjust to local, economy-wide price developments.

[25] On the other hand, Heise et al. (2021) find that job-to-job transition rates are a weak instrument for wage growth in their setting. While the instrument is stronger for services, it is weak across both sectors. We posit that this is due to their choice of sample period (before the COVID-19 pandemic), as our instrument is also weaker when restricting to the period before the COVID-19 pandemic.

increase.[26] Given that services sectors tend to be more labor-intensive, this can explain their higher estimated pass-through.[27] To provide insight into the extent to which pass-through is based on fundamental characteristics of a sector, we investigate how pass-through is mediated by a sector's labor intensity. We estimate a version of the local projection specification with $h = 0$ using observations before 2020:[28]

$$\begin{aligned}\Delta \ln(p_{it}) = \alpha + \beta\lambda_{it}\Delta \ln(w_{it}) + \sum_{j=1}^{2} \delta_j \Delta \ln(p_{i,t-j}) + \sum_{j=1}^{2} \psi_j \lambda_{i,t-j} \cdot \Delta \ln(w_{i,t-j}) \\ + \gamma \mathbf{X_{it}} + \xi_i + \rho_t + \varepsilon_{i,t}\end{aligned} \tag{2}$$

where for sector $i$ and quarter $t$, $\Delta \ln(p_{it})$ and $\Delta ln(w_{it})$ are the four-quarter log changes in prices and wages, $\lambda_{it}$ is labor share, $\lambda_{i,t-j}$ is lagged labor share, $\Delta \ln(p_{i,t-j})$ and $\Delta ln(w_{i,t-j})$ are lagged four-quarter log changes in price and wages, $\mathbf{X_{it}}$ is a vector of controls (four-quarter log changes in total factor productivity, import prices, and input prices), $\xi_i$ is a sector fixed effect, and $\rho_t$ is a quarter fixed effect. We weight the regression by a sector's share in the total nominal PCE and use Driscoll-Kraay standard errors with a lag of two quarters.

Labor share is an important determinant of pass-through, but is far from 100 percent even in sectors that completely rely on labor as inputs (Table 1). The coefficient on the interaction term indicates that in sectors with a labor share of 1 the contemporaneous pass-through is 48.7 percent ($p = 0.063$) in goods sectors and 25.7 percent ($p = 0.001$) in services sectors. While the coefficient on the interaction

[26] Empirically, trends in labor shares can be both structural and cyclical. Overall, labor share has been declining in the U.S. and globally. Structural trends include global integration, technological progress, and the price of investment goods (Dao et al. 2017, Elsby et al. 2013, Karabarbounis and Neiman 2013). During economic downturns, total sectoral activity tends to decline faster than workers' earnings, leading to a higher labor share (Shao and Silos 2014, Young 2004).

[27] In 2019, the average labor share was 25.3 percent in goods sectors and 34.5 percent in services sectors.

[28] To improve the power of the estimation, in the rest of the paper, we use 2 lags of $\Delta \ln(p_{it})$ and $\Delta ln(w_{it})$, but the estimates are qualitatively similar when 8 lags are used (Appendix B.4).

term in goods sectors suggests that pass-through is higher in goods sectors relative to services sectors with high labor shares, the pass-through declines to zero in all subsequent quarters, indicating either that pass-through is extremely transitory in goods sectors or that the higher pass-through is a false positive (Appendix B.4).

Table 1: Pass-through accounting for labor share

| | Goods sectors | | Services sectors | |
|---|---|---|---|---|
| | w/o labor share | w/ labor share | w/o labor share | w/ labor share |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.0780 | | 0.117*** | |
| | (0.050) | | (0.033) | |
| Δ wage · labor share | | 0.487* | | 0.257*** |
| | | (0.255) | | (0.073) |
| Δ productivity | -0.00236 | -0.00258 | -0.0269 | -0.0287 |
| | (0.032) | (0.032) | (0.023) | (0.023) |
| Δ import price | 0.207*** | 0.204*** | | |
| | (0.057) | (0.058) | | |
| Δ input price | 0.216*** | 0.216*** | 0.0463*** | 0.0470*** |
| | (0.074) | (0.075) | (0.006) | (0.007) |
| N | 1002 | 1002 | 1216 | 1216 |
| R2 | 0.818 | 0.817 | 0.647 | 0.645 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price growth to wage growth (columns 1 and 3) and to wage growth interacted with sectoral labor share (columns 2 and 4). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 2) with wage growth or an interaction between contemporaneous wage growth and labor share, two lags of price growth, two lags of wage growth or an interaction between labor share and wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Sample period is restricted to years prior to 2020. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

# 5 Is pass-through different in the COVID-19 pandemic recovery?

Given the concurrent acceleration in price and wage inflation during the COVID-19 pandemic recovery, a key question emerges of whether the pass-through from

wage growth to price growth has increased during this period. While the level of pass-through has not exhibited obvious structural breaks in either goods and services sectors in the decade prior to the COVID-19 pandemic, we find that pass-through is higher in both goods and services sectors during the COVID-19 recovery.

## 5.1 Historical stability of pass-through

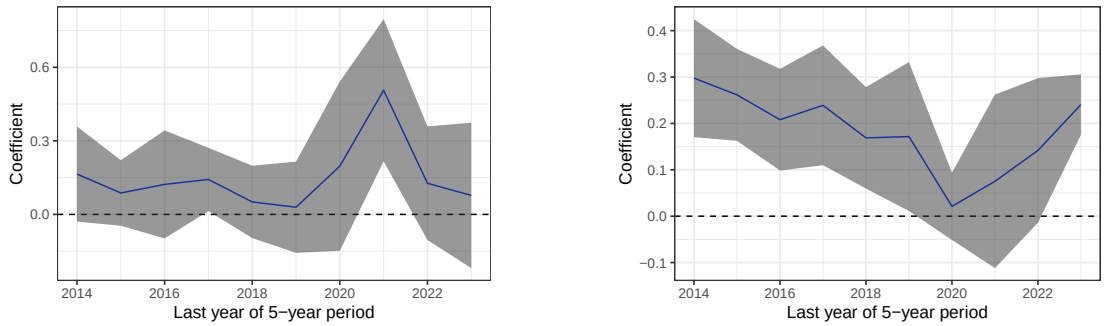
We estimate Equation 1 using a 5-year rolling window and calculate the peak pass-through, or the largest pass-through estimate over an eight-quarter horizon.

There has been variation in pass-through across time and with different trends across sectors (Figure 7). In goods sectors prior to 2020, pass-through has remained around 15 percent since 2014, then declining slightly in 2018-19. In services sectors prior to 2020, pass-through has been high but steadily declining from 29.8 percent in 2014 to 17.2 percent in 2019.

Visually, there is no evidence of a structural break in the years leading up to the COVID-19 pandemic recovery. During the COVID-19 pandemic recovery, both goods and services sectors experienced a sharp increase in pass-through, which has since declined in goods sectors but has remained elevated in services sectors. We next turn to an explicit study of the COVID-19 pandemic recovery.

## 5.2 Pass-through in the COVID-19 pandemic recovery

We test whether pass-through is stronger during the COVID-19 pandemic recovery using a version of the local projection specification for $h = 0$ (in other words, the contemporaneous pass-through) and include an interaction term between wage growth and an indicator variable for the COVID-19 pandemic recovery (defined




(a) Goods sectors

(b) Services sectors

Figure 7: Peak pass-through coefficients in rolling window regressions

*Note:* The figures plot the largest impulse response of price growth to wage growth over an eight-quarter horizon. The horizontal axis represents the last year in the five-year period used for estimation. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

as the first quarter of 2021 and after):[29]

$$\Delta \ln(p_{it}) = \alpha + \beta_1 \Delta \ln(w_{it}) + \beta_2 \Delta \ln(w_{it}) I_t + \sum_{j=1}^{2} \delta_j \Delta \ln(p_{i,t-j}) + \sum_{j=1}^{2} \zeta_j \Delta \ln(w_{i,t-j}) + \gamma \mathbf{X_{it}} + \xi_i + \rho_t + \varepsilon_{i,t} \tag{3}$$

where for sector $i$ and quarter $t$, $\Delta \ln(p_{it})$ and $\Delta ln(w_{it})$ are the four-quarter log changes in prices and wages, $\mathbf{X_{it}}$ is a vector of controls (total factor productivity, import prices, and input prices), $I_t$ is an indicator variable equal to 1 if $t$ is 2021Q1 or after, $\xi_i$ is a sector fixed effect, and $\rho_t$ is a quarter fixed effect. We weight the regression by a sector's share in the total nominal consumption expenditure and use Driscoll-Kraay standard errors with a lag of two quarters. We include data from the COVID-19 pandemic recovery sequentially by quarter to examine how pass-through evolved during the recovery.

We again find differential trends across sectors (Figure 8). While initially

[29] We focus on contemporaneous pass-through, rather than longer time horizons, due to the limited availability of data in the COVID-19 pandemic recovery.

elevated in goods sectors – contemporaneous pass-through was 58.0 percent higher ($p < 0.001$) compared to prior to the COVID period in the first quarter of 2021 – pass-through moderated by the fourth quarter of 2021 and was not significantly different from pass-through prior to the COVID-19 pandemic recovery.

Conversely, in services sectors, after initially increasing 19.6 percent in the first quarter of 2021, the increase in contemporaneous pass-through moderated to close to 10 percent but has remained elevated.

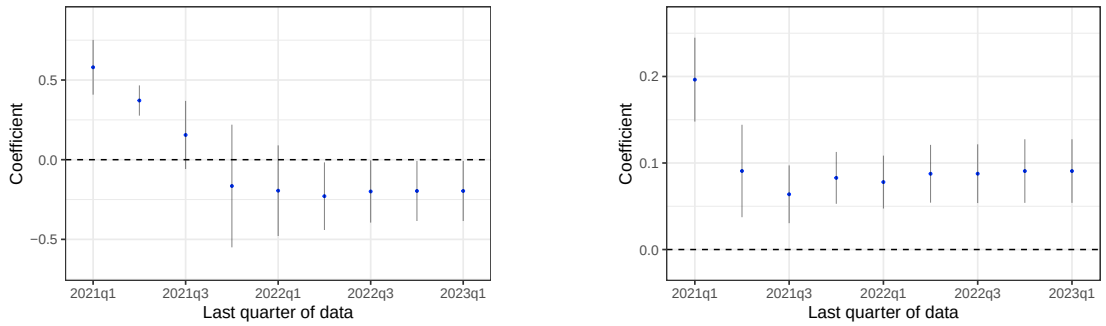
The estimated coefficients on the interaction term implies that higher pass-through in the COVID-19 pandemic recovery increased contemporaneous goods inflation by about 0.8 percentage points by the third quarter of 2021 and contemporaneous services inflation by about 0.7 percentage points by end-2021 and by about 0.5 percentage points by end-2022 (Panels a and c of Figure 9). When the persistence of inflation is taken into account in a dynamic counterfactual, the higher pass-through in the COVID-19 pandemic recovery increased contemporaneous goods inflation by about 1 percentage point by the third quarter of 2021 and contemporaneous services inflation by about 0.8 percentage points in the second quarter of 2021 (Panels b and d of Figure 9).[30]

# 6 Why did pass-through increase in the COVID-19 pandemic recovery?

Despite exhibiting decreasing trends in the decade prior to the COVID-19 pandemic, contemporaneous pass-through increased during the COVID-19 pandemic recovery. While fundamentals such as labor share are important determinants of pass-through, they are unlikely to explain the increase.[31] In this section, we discuss

[30] In the static counterfactual, the lagged price growth values are the actual realized price growth values. In the dynamic counterfactual, the lagged price growth values are updated with the predicted price growth values.

[31] In 2020, non-farm business labor share of income increased by 3.2 percent. Using the coefficient in Table 1, this implies a 0.8 percentage point increase in pass-through in services sectors.




(a) Goods sectors

(b) Services sectors

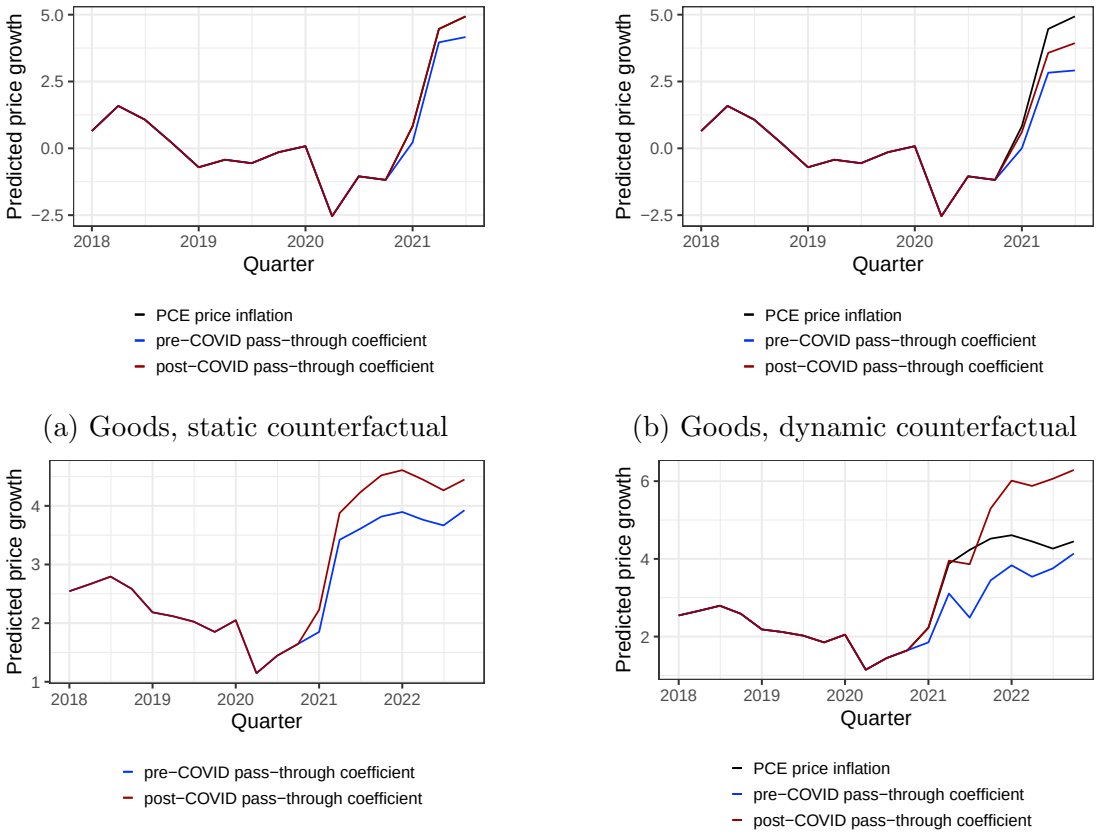
Figure 8: Contemporaneous pass-through in the COVID-19 pandemic recovery

*Note:* The figures plot the contemporaneous impulse response of price growth to the interaction of wage growth with a post-COVID indicator variable. The horizontal axis represents the last quarter of data used for estimation. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The vertical black lines represent the 90% confidence interval. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

whether these indicate a structural change or whether these reflect concurrent economic developments. This distinction determines whether the pass-through from wage growth to price growth will be different going forward or will decline once recent economic developments subside. We find stronger evidence that recent economic developments explain the increased pass-through. High wage growth in services sectors and strong demand in goods sectors have driven the increased pass-through, while supply-side disruptions have contributed to inflation but not the increased pass-through.

## 6.1 High wage growth

One of the prevailing narratives during the COVID-19 pandemic recovery has been the high growth in nominal wages. With faster wage growth, firms are less able to absorb wage increases in their markups. We estimate the contemporaneous impulse response prior to 2020 and test whether pass-through is higher in periods of high wage growth. In other words, we estimate a version of Equation 3 but use the interaction of wage growth and a measure of high wage growth. We define high




(a) Goods, static counterfactual

(b) Goods, dynamic counterfactual

(c) Services, static counterfactual

(d) Services, dynamic counterfactual

Figure 9: Inflation with different pass-through counterfactuals

*Note:* The figures plot the predicted price growth for goods and services sectors for a static counterfactual (Panel a, c) and a dynamic counterfactual (Panel b, d). In the static counterfactual, predicted price growth is based off actual past price growth values. In the dynamic counterfactual, predicted price growth is based off predicted past price growth values. In each figure, the blue line plots the predicted values of price growth using the pre-COVID pass-through estimate (which is equal to $\beta_1$ in Equation (3) and the red line plots the predicted values of price growth using the post-COVID pass-through estimate (which is equal to $\beta_1 + \beta_2$ in Equation (3). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

wage growth as an indicator variable equal to 1 for sector-years where four-quarter wage growth exceeds the 75 percentile in the sample, or 4.1 percent.

Consistent with our hypothesis, during periods with high wage growth, contemporaneous pass-through is 9.1 percentage points higher ($p = 0.088$) in services sectors prior to the COVID-19 pandemic (Column 2 of Table 2). The magnitude of this increase in services sectors is comparable to the magnitude of the increase in pass-through during the COVID-19 pandemic recovery, suggesting that high wage growth could be driving the increase in pass-through during the COVID-19

pandemic recovery.

To test the extent to which high wage growth drove the increase in pass-through during the COVID-19 pandemic recovery, we augment Equation 3 with an interaction between contemporaneous wage growth and a dummy for the COVID-19 pandemic recovery and use the full sample between 2010-2023. The pattern of higher pass-through during periods of high wage growth is also borne out and stronger when including the COVID-19 pandemic recovery, with contemporaneous pass-through increasing by 13.6 percent ($p = 0.007$) (Column 3 of Table 2). Further, the reduction in the coefficient on the interaction of wage growth and the post-COVID indicator variable suggests that most of the increase in pass-through in the post-COVID recovery period is explained by high wage growth.[32][33]

Pass-through in goods sectors, on the other hand, does not materially change during periods of high wage growth, and is not statistically significant when including years during the COVID-19 pandemic recovery (Columns 1 and 3 of Table 2). Given evidence that international competition and market competition have reduced pass-through in goods sectors (Heise et al. 2021), this finding suggests that firms in goods sectors have difficulty passing on higher labor costs into prices.

We also examine whether labor market tightness more broadly, as measured by the vacancy-to-unemployment ratio, leads to higher pass-through but do not find that this is the case (Appendix B.4). There are a couple of reasons why tight labor markets do not lead to higher pass-through. The most obvious is that the measured vacancy-to-unemployment ratios are not adequate indicators for labor market tightness. Importantly, the ratios are only available at the more aggregated 2-digit level and may not capture labor market dynamics at the more

[32]We also estimate the impulse response for different values of $h$. The coefficient on the interaction of wage growth with periods of high wage growth peaks at quarter 3 at about 30 percent using the pre-COVID sample and at about 40 percent using the full sample.

[33]We also observe a positive coefficient on productivity growth which is counterintuitive. This may be due to our use of 1-digit sectoral productivity data after 2021, since the more granular sectoral productivity data was not available.

granular industry, and thus sectoral, level we examine in this paper. Another issue is that industry-level ratios may not be the most relevant partition of labor markets, versus for example occupational-level ratios. Finally, empirically, wage growth does not always increase when the vacancy-to-unemployment ratio rises (Appendix B.4).

Table 2: Pass-through in periods with high wage growth

| | Pre-COVID (2010-2019) | | All years (2010-2023) | |
|---|---|---|---|---|
| | Goods | Services | Goods | Services |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.135** | 0.0939** | 0.130*** | 0.0588 |
| | (0.052) | (0.045) | (0.045) | (0.040) |
| Δ wage · high Δ wage | -0.127* | 0.0914* | -0.0671 | 0.136*** |
| | (0.066) | (0.052) | (0.083) | (0.049) |
| Δ wage · postCOVID | | | -0.173 | 0.0127 |
| | | | (0.132) | (0.036) |
| Δ productivity | 0.00284 | -0.0298 | -0.0102 | 0.0396* |
| | (0.030) | (0.023) | (0.042) | (0.021) |
| Δ import price | 0.205*** | | 0.150** | |
| | (0.057) | | (0.062) | |
| Δ input price | 0.220*** | 0.0464*** | 0.342*** | 0.0805*** |
| | (0.075) | (0.006) | (0.068) | (0.016) |
| N | 1002 | 1216 | 1374 | 1648 |
| R2 | 0.819 | 0.649 | 0.827 | 0.729 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with an indicator for high wage growth. High wage growth is defined as sector-years with wage growth above the 75th percentile. Price and wage growth are the four-quarter log changes in the PCE price index and wage, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction of wage growth with a post-COVID indicator variable (Columns 3 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

## 6.2 Supply shocks

Supply-side disruptions have been another frequently cited driver of inflation during the COVID-19 pandemic recovery (for example, see Akinci et al. 2022). Disrupted supply chains increased import and input costs, then were passed onto final goods prices. In addition to this direct effect, Amiti et al. (2022) argue that the simultaneous increase in wages and input prices created an amplification effect that reduced the ability of firms to substitute between the two factors of production, thereby increasing pass-through.

We augment Equation 3 with the interactions of import price and input price growth with wage growth. We find that supply shocks contribute directly to inflation – pass-through from import prices and input prices to final goods prices are large and statistically significant – but do not find strong evidence of an amplification effect (Table 3). In services sectors, the coexistence of a wage and input price shock increases pass-through by 39.9 percent ($p = 0.100$). However, the amplification effect appears to be driven by the COVID-19 pandemic recovery and may be a false positive. When examining only years prior to the COVID-19 pandemic recovery, the coefficient declines in magnitude, 10.6 percent, and is not statistically different from zero ($p = 0.733$). In goods sectors, we do not find evidence of an amplification effect whether including or excluding years in the COVID-19 pandemic recovery. The coefficient on the interaction terms of wage growth and import or input price growth are either negative or not statistically distinguishable from zero.

Our results contrast with those of Amiti et al. (2022), who use the Producer Price Index to provide cross-sectional evidence of an amplification effect in goods sectors but not in services sectors. In Appendix B.4, we are unable to find an amplification effect in either goods or services sectors after replicating their study.[34]

[34]Namely, we limit the sample period to quarters prior to the third quarter of 2021 (the latest quarter of data available in Amiti et al. (2022)) and estimate their specification.

We conclude that differences in the underlying data and the analysis of final goods prices, versus producer prices, drive the difference in our findings.

Table 3: Pass-through accounting for supply shocks

| | Pre-COVID (2010-2019) | | All years (2010-2023) | |
|---|---|---|---|---|
| | Goods | Services | Goods | Services |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.138 | 0.117*** | 0.112** | 0.0876*** |
| | (0.088) | (0.033) | (0.047) | (0.030) |
| Δ wage · postCOVID | | | -0.425* | 0.0499* |
| | | | (0.243) | (0.028) |
| Δ wage · Δ import price | -5.847*** | | -5.106*** | |
| | (1.737) | | (1.304) | |
| Δ wage · Δ input price | 1.568 | 0.106 | 3.605 | 0.399* |
| | (3.061) | (0.310) | (2.254) | (0.238) |
| Δ productivity | -0.0142 | -0.0270 | -0.0331 | 0.0391* |
| | (0.031) | (0.023) | (0.035) | (0.021) |
| Δ import price | 0.367*** | | 0.322*** | |
| | (0.083) | | (0.078) | |
| Δ input price | 0.173 | 0.0441*** | 0.225* | 0.0654*** |
| | (0.109) | (0.009) | (0.116) | (0.014) |
| N | 1002 | 1216 | 1374 | 1648 |
| R2 | 0.829 | 0.647 | 0.833 | 0.728 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with import and input price growth. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction between wage inflation and a post-COVID indicator variable (Columns 3 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

## 6.3 Elevated demand in goods sectors

During the economic shutdown in the early months of the COVID-19 pandemic, there was a significant shift in demand towards goods consumption (Panel a of Figure 10). This shift, together with the fiscal transfers distributed in 2020

and 2021 and short-run inelastic supply, led to strong excess demand in goods sectors. Strong excess demand can contribute directly to inflation but can also increase pass-through by providing firms with more pricing power, as they are less likely to lose market share if they raise prices. Empirically, there is a strong positive correlation between demand and inflation during the COVID-19 pandemic recovery (Panel b of Figure 10), despite wage growth increasing by a smaller magnitude (Panel c of Figure 10). We test whether excess demand, like supply-side disruptions, can explain the elevated pass-through in goods sectors.

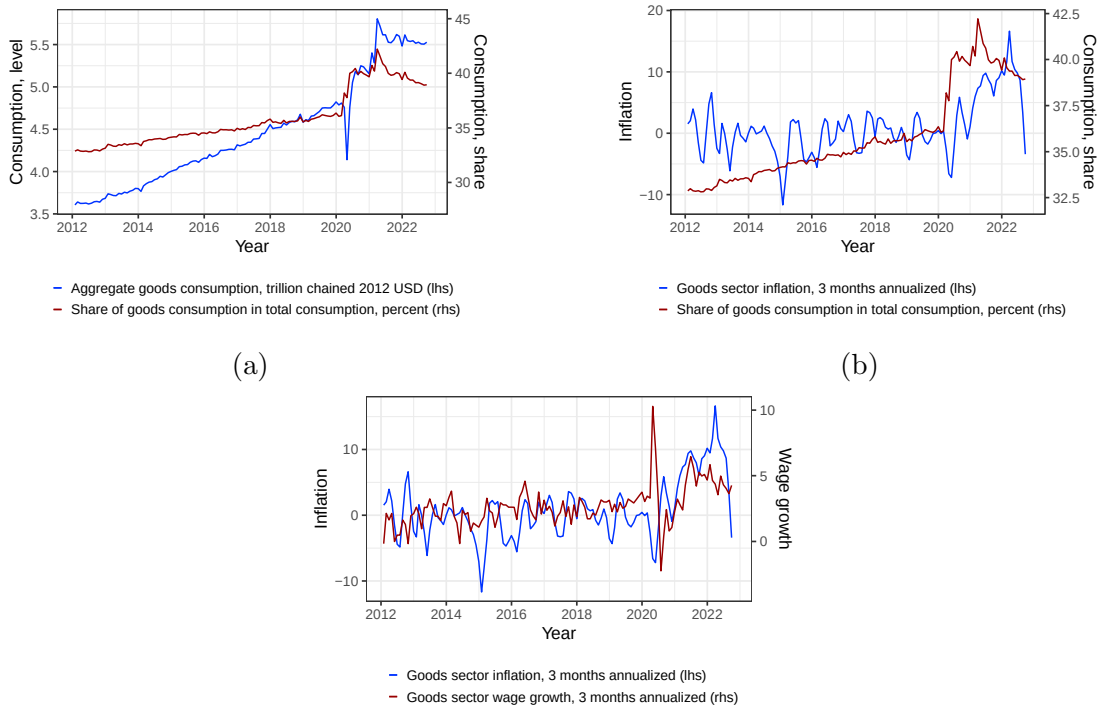



Figure 10: Goods sector consumption, wage-growth and inflation during the COVID-19 pandemic recovery

*Note:* The figures plot aggregate goods consumption, the share of goods consumption in total consumption, goods sector wage growth (3 months changes, annualized) and goods sector PCE price inflation (3 months changes, annualized). *Source:* BLS, BEA, and authors' calculations.

We augment Equation 3 with the interaction of the deviation of sectoral PCE from trend, which we refer to as the demand gap, and wage growth.[35] We esti-

[35]We proxy sectoral goods consumption with the share of sectoral spending in total spending, as the level of sectoral spending can be endogenous to wage growth. The share of goods consumption is closely linked to the level of consumption (Panel a of Figure 10).

mate pass-through in goods sectors and both exclude the COVID-19 pandemic recovery and include quarters up to the third quarter of 2021 (corresponding to the quarters with elevated pass-through in goods sectors during the COVID-19 pandemic recovery).

There is evidence that excess demand in goods sectors has increased pass-through during the COVID-19 pandemic recovery by 295 percent ($p < 0.001$), although it did not do so prior to the COVID-19 pandemic recovery (Table 4)[36].Given the little variation in excess demand prior to the COVID-19 pandemic recovery, excess demand likely did not play a role in affecting pass-through during this period. The coefficient on the demand gap also suggests that higher excess demand corresponds with lower inflation, which is counter-intuitive.[37] This suggests that, at a sectoral level, demand substitutes to cheaper consumption categories. It is possible this reversed during the COVID-19 pandemic recovery given the generalized inflation that occurred, reducing the ability to substitute to cheaper consumption categories. We find further support that excess demand played a role in increasing pass-through during the COVID-19 pandemic recovery, as the coefficient on the interaction between the post-COVID indicator variable and wage growth reverses sign.

# 7 Conclusion

We study the pass-through of labor costs to prices of final consumer goods and services using sectoral data. We link industry-level wages to consumer prices, allowing us to trace the pass-through of labor costs to consumer prices for each final goods sector. We find that, prior to the COVID-19 pandemic, pass-through

[36]We also estimate the impulse response including data from the COVID-19 pandemic recovery sequentially by quarter. The coefficient on the interaction of wage growth with elevated demand peaks at 378 percent in 2021Q1 but then dissipates quickly throughout 2021.

[37]A simple scatter plot of sectoral excess demand and inflation indeed shows a negative correlation (results available upon request).

Table 4: Pass-through accounting for excess demand in goods sectors

| | Pre-COVID (2010-2019) (1) | COVID recovery (2010-2021Q3) (2) |
|---|---|---|
| Δ wage | 0.0695 | 0.0930* |
| | (0.047) | (0.053) |
| Δ wage · demand gap | -0.165 | 2.950*** |
| | (1.363) | (0.720) |
| demand gap | -0.195*** | -0.0676** |
| | (0.069) | (0.027) |
| Δ wage · postCOVID | | -0.530** |
| | | (0.233) |
| Δ productivity | 0.00358 | -0.00831 |
| | (0.037) | (0.045) |
| Δ import price | 0.211*** | 0.211*** |
| | (0.057) | (0.054) |
| Δ input price | 0.224*** | 0.317*** |
| | (0.079) | (0.069) |
| N | 1002 | 1250 |
| R2 | 0.826 | 0.827 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with the demand gap. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction between wage inflation and a post-COVID indicator variable (Column 2), the demand gap, two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

in goods sectors has been around zero and in services sectors about 10 percent on impact, then rising to over 25 percent in three quarters. We document a significant increase in pass-through in the COVID-19 pandemic recovery. Contemporaneous pass-through in goods sectors increased by over 50 percent in 2021 then quickly declined by the end of 2021 and in services sectors by about 10 percent throughout the COVID-19 pandemic recovery. Given the high level of wage growth and the persistent process of inflation, our estimates suggest that the increase in contemporaneous pass-through increased contemporaneous goods inflation by about

0.8 percentage points by the third quarter of 2021 and contemporaneous services inflation by about 0.7 percentage points by end-2021 and by about 0.5 percentage points by end-2022.

We find that high wage growth has been the key driver of the increase in pass-through in services sectors. In goods sectors, we find evidence that excess demand helped push up pass-through. Supply-side disruptions contributed to inflation but did not lead to higher pass-through. Our analysis suggests that pass-through should decline as labor markets and goods markets continue to re-balance and that a vicious wage-price spiral is not likely to occur. Part of this re-balance will occur naturally, as the pandemic-related fiscal impulse fades, savings accumulated during the COVID-19 pandemic are drawn down, and global supply chains normalize. However, tighter monetary policy than prior to the COVID-19 pandemic will be needed to re-balance labor markets, in light of the persistent shortfall in labor participation during the COVID-19 pandemic recovery.

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# Online Appendix

# The Pass-through of Wages to Consumer Prices in the COVID-19 Pandemic: Evidence from Sectoral Data in the U.S.

Moya Chin Li Lin

## Contents

# A Data appendix

Data sources for labor costs, prices of consumption goods, productivity, input prices, and import prices are provided in Section 2. In addition,

***Job openings, Vacancy-to-unemployment ratio:*** Vacancy rates and job opening rates are from the the Job Openings and Labor Turnover Survey (Bureau of Labor Statistics 2001-2022*b*) and are at the 2-digit NAICS industry level. These are matched to the unemployment rate by industry to create the vacancy-to-unemployment ratio. Industry-level unemployment rates are from the Labor Force Statistics from the Current Population Survey (Bureau of Labor Statistics (1948-2022*c*)).

***Labor share:*** We use annual labor shares from the Integrated Industry-Level Production Account (Bureau of Economic Analysis 1987-2020) and the Annual Labor Productivity and Costs by Detailed Industry (Bureau of Labor Statistics 1987-2023). Data from the Integrated Industry-Level Production Account were used to supplement for industries missing in the Annual Labor Productivity and Costs by Detailed Industry. This was calculated in the Integrated Industry-Level Production Account as the share of non-college and college labor compensation out of gross output.

***Demand:*** We use the monthly real personal consumption expenditures in chained 2012 dollars (Bureau of Economic Analysis 2002-2023*a*) and use growth in the monthly real personal consumption expenditures quantity indexes (Bureau of Economic Analysis 1959-2023*b*) to back-construct the chained series to 1990. The demand gap is calculated as the ratio of the deviation of demand from its trend component. The trend component of demand is calculated using a Hodrick-Prescott filter with a smoothing parameter of 129600.

***Job to job transitions:*** We use the quarterly job-to-job transition rate (calculated using separations) from the Longitudinal Employer-Household Dynamics

(LEHD) (Census Bureau 2000-2021). The job-to-job transition data are available at the 2-digit industry level, separated by gender, education level or age-group. Following Heise et al. (2021), the job-to-job transition rate for industries at the 3-digit and 4-digit levels are a weighted average of the job-to-job transition rate of the corresponding two-digit industry by gender (or education level, or age group), with the weight being the the gender, education and age group shares of workers at the 3-digit and 4-digit level. The share of workers by demographic characteristics are calculated using the quarterly, industry-level employment by gender, education level and age group from the Quarterly Workforce Indicators (Census Bureau 1990-2020).

The following data sources were used for the analysis on the impulse response of wages to inflation in Appendix B.5.

***Consumer price index (CPI):*** We use the Consumer Price Index for All Urban Consumers (CPI-U, all items) for 23 metropolitan areas (Bureau of Labor Statistics 1998-2022*a*). The data are of different frequencies (monthly, bi-monthly, and semi-annually, or a combination of the above). We combine data of different frequencies and fill in missing months using linear interpolation to generate monthly price levels. Inflation is defined as the twelve-month change in the price index. The final dataset contains data for most metropolitan areas between 1999-2002, for 22 metropolitan areas for 2003-2018, and for all metropolitan areas for 2019-2022.

***Wages at the metropolitan level:*** We use regional-level wage data from the monthly "total private average hourly earnings of all employees" from the State and Metro Area database of Current Employment Statistics (Bureau of Labor Statistics 2007-2022*e*). Data are available for 18 metropolitan areas for 2007-2010 and for all 23 metropolitan areas for 2011-2022.

***Unemployment rate at the metropolitan level:*** We use regional-level

unemployment rate data (Bureau of Labor Statistics 1990-2022*d*) from the Local Area Unemployment Statistics. Data are available from 1990 for all 23 metropolitan areas. We calculate the unemployment gap as the difference between the unemployment rate and the average unemployment rate between 2009 and 2019.

***Union coverage, share of part-time workers, share of self-employed workers and share of workers who are paid hourly at the metropolitan level*** are constructed from the IPUMS-Current Population Survey (University of Minnesota (1991-2021)). Data are available for 4 metropolitan areas from 1990, for 14 metropolitan areas from 2005, and for 22 metropolitan areas from 2015.

# B Additional tables and figures

## B.1 Trends in inflation and wage growth

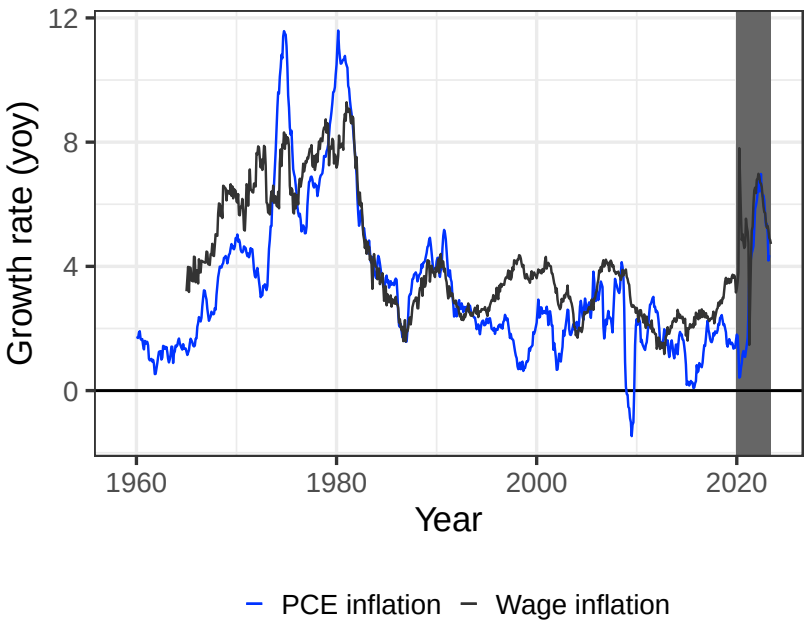



Figure B.1: Historical time series of PCE and wage inflation

*Note:* The figure plots the time series of wage growth and price growth. Price and wage growth are the twelve-month log changes in the PCE price index and wages, respectively, and at a monthly frequency. Price growth uses the PCE price index. Wage growth uses the hourly earnings of production and nonsupervisory employees from the CES database. *Source:* BLS, BEA, and authors' calculations.

Table B.1: Output sectors with highest and lowest wage growth, 1990-2020

| Sector | Wage growth |
|---|---|
| New motor vehicles | 1.58 |
| Motor vehicle parts and accessories | 1.72 |
| Water transportation | 2.00 |
| Video and audio equipment | 2.14 |
| Sports and recreational vehicles | 2.21 |
| Telephone and facsimile equipment | 2.31 |
| Pharmaceutical and other medical products | 2.33 |
| Household supplies | 2.34 |
| Food furnished to employees (including military) | 2.38 |
| Household maintenance | 2.39 |
| Magazines, newspapers, and stationery | 3.39 |
| Hospitals | 3.41 |
| Air transportation | 3.48 |
| Net motor vehicle and other transportation insurance | 3.48 |
| Net health insurance | 3.48 |
| Life insurance | 3.48 |
| Net household insurance | 3.48 |
| Physician services | 3.78 |
| Financial services furnished without payment | 3.93 |
| Financial service charges, fees, and commissions | 3.99 |

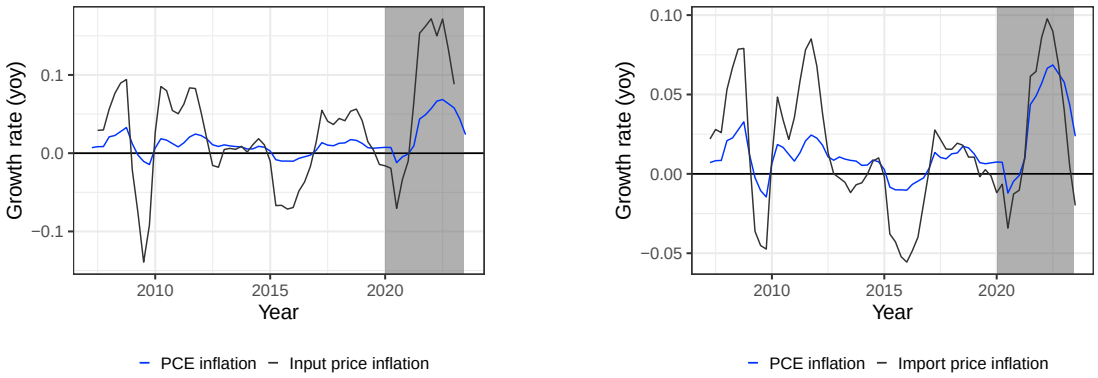
*Note:* The table presents the output sectors with the bottom 10 and top 10 average wage growth between 1990-2020. Wage growth is the four-quarter log change in wages and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

Table B.2: Output sectors with highest and lowest wage growth, 2021-2023

| Sector | Wage growth |
|---|---|
| Telecommunication services | 0.0913 |
| Internet access | 0.2119 |
| Audio-video, photographic, and information processing equipment services | 1.7300 |
| Magazines, newspapers, and stationery | 2.4745 |
| New motor vehicles | 2.9413 |
| Information processing equipment | 3.0854 |
| Children's and infants' clothing | 3.2255 |
| Pharmaceutical and other medical products | 3.2583 |
| Membership clubs, sports centers, parks, theaters, and museums | 3.7456 |
| Photographic equipment | 3.8797 |
| Nursing homes | 7.0952 |
| Air transportation | 7.2364 |
| Household appliances | 7.4368 |
| Motor vehicle parts and accessories | 7.6932 |
| Ground transportation | 8.0518 |
| Personal care and clothing services | 9.1242 |
| Purchased meals and beverages | 9.6163 |
| Group housing | 10.8036 |
| Accommodations | 10.8036 |
| Telephone and facsimile equipment | 16.3646 |

*Note:* The table presents the output sectors with the bottom 10 and top 10 average wage growth between 2021-2023. Wage growth is the four-quarter log change in wages and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

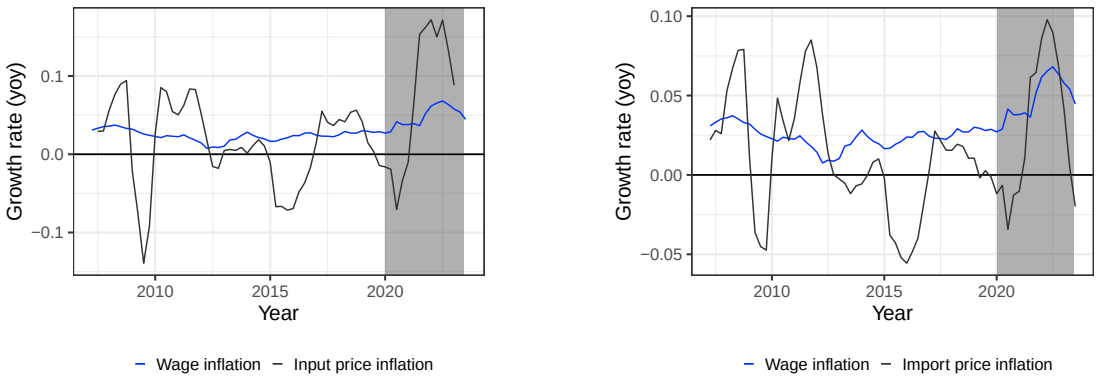
## B.2 Excluding controls for input and import prices




(a) Input prices (b) Import prices

Figure B.2: Historical time series of PCE and input and import price inflation

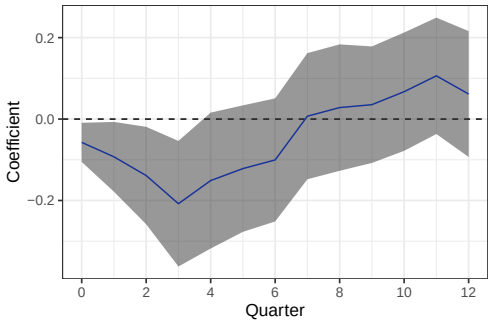
*Note:* The figures plot the time series of average price growth and input price (panel A) and import price (panel B) growth across output sectors. Price growths are the four-quarter log changes and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.



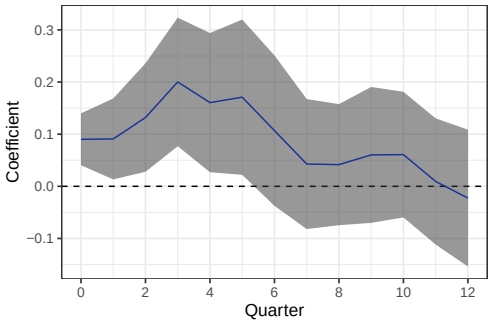

(a) Input prices (b) Import prices

Figure B.3: Historical time series of wage and input and import price inflation

*Note:* The figures plot the time series of average wage growth and input price (panel A) and import price (panel B) growth across output sectors. Wage growth and price growths are the four-quarter log changes and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.



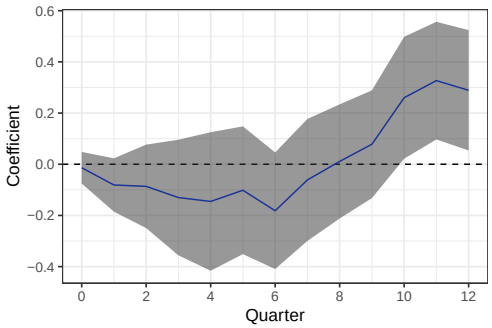

(a) Goods sectors



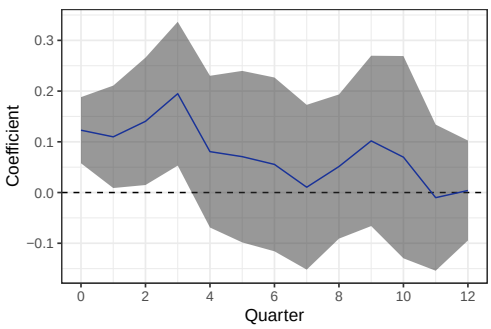

(a) Services sectors

Figure B.4: Impulse responses of price inflation to wage inflation, without import and input prices

*Note:* The figures plot the estimated pass-through of wage growth to price growth at different quarterly horizons. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log change in productivity as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.




(a) Goods sectors




(a) Services sectors

Figure B.5: Impulse responses of price inflation to wage inflation, without import and input prices and restricting sample to 2010-2023

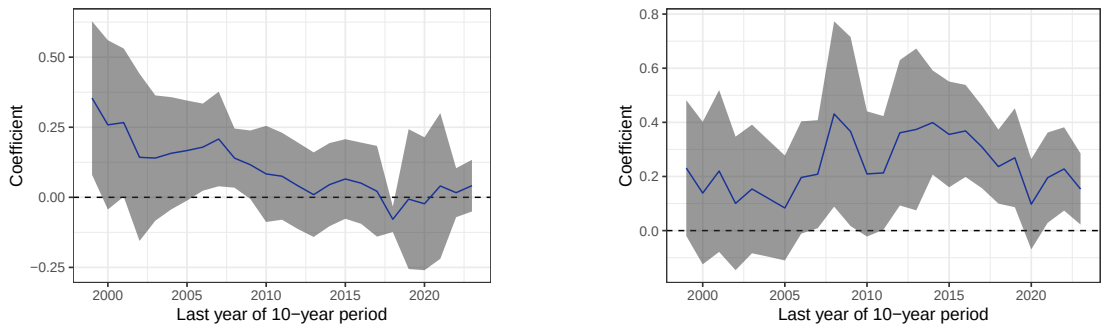
*Note:* The figures plot the estimated pass-through of wage growth to price growth at different quarterly horizons. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log change in productivity as controls. Sample period is restricted to 2010-2023. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.3: Pass-through accounting for labor share, without import and input prices

| | Goods sectors | | Services sectors | |
|---|---|---|---|---|
| | w/o labor share | w/ labor share | w/o labor share | w/ labor share |
| | (1) | (2) | (3) | (4) |
| Δ wage | -0.0415 | | 0.124*** | |
| | (0.040) | | (0.038) | |
| Δ wage · labor share | | -0.267 | | 0.236*** |
| | | (0.274) | | (0.083) |
| Δ productivity | -0.0474 | -0.0497 | -0.0313 | -0.0347 |
| | (0.047) | (0.048) | (0.023) | (0.024) |
| N | 1222 | 1222 | 1502 | 1502 |
| R2 | 0.726 | 0.726 | 0.671 | 0.670 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price growth to wage growth (columns 1 and 3) and to wage growth interacted with sectoral labor share (columns 2 and 4). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 2) with wage growth or an interaction between contemporaneous wage growth and labor share, two lags of price growth, two lags of wage growth or an interaction between labor share and wage growth, sector fixed effects, time fixed effects, and four-quarter log change in productivity as controls. Sample period is restricted to years prior to 2020. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

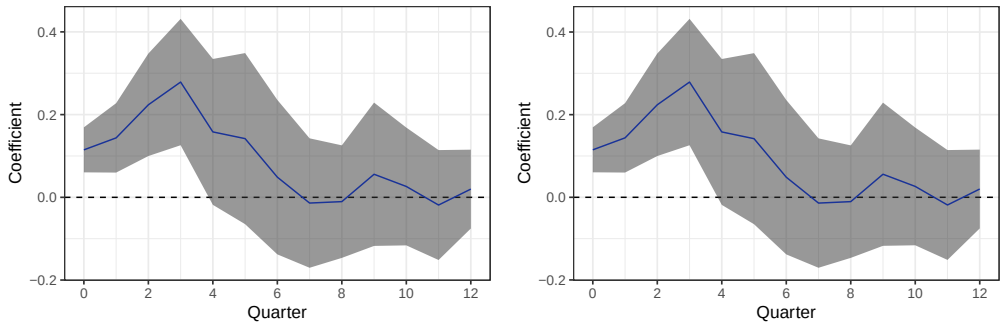



(a) Goods sectors (b) Services sectors

Figure B.6: Peak pass-through coefficients in rolling window regressions, without import and input prices

*Note:* The figures plot the largest impulse response of price growth to wage growth over an eight-quarter horizon. The horizontal axis represents the last year in the ten-year period used for estimation. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log change in productivity as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

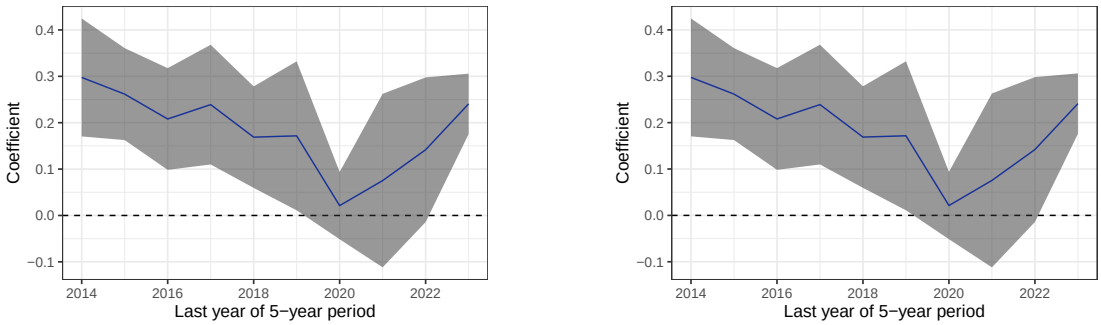
## B.3 Results for non-shelter services




(a) Services sectors (b) Non-shelter services sectors

Figure B.7: Impulse responses of price inflation to wage inflation

*Note:* The figures plot the estimated pass-through of wage growth to price growth at different quarterly horizons. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.




(a) Services sectors (b) Non-shelter services sectors

Figure B.8: Peak pass-through coefficients in rolling window regressions

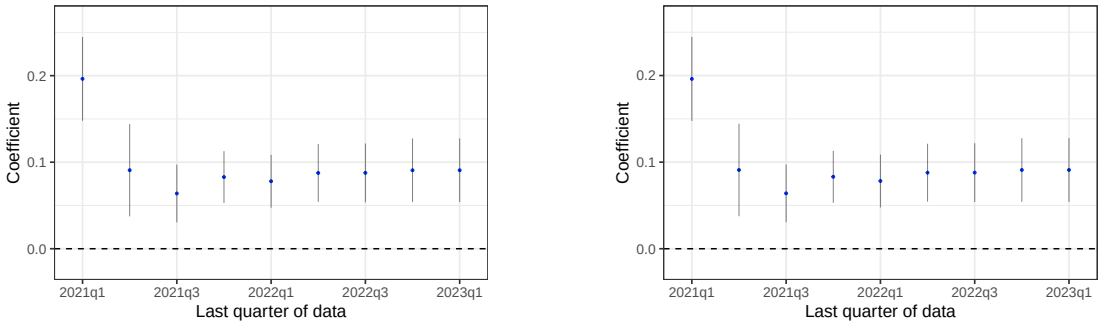
*Note:* The figures plot the largest impulse response of price growth to wage growth over an eight-quarter horizon. The horizontal axis represents the last year in the five-year period used for estimation. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 1) with eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.4: Pass-through accounting for labor share

| | Without labor share | | With labor share | |
|---|---|---|---|---|
| | services | non-shelter | services | non-shelter |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.117*** | 0.117*** | | |
| | (0.033) | (0.033) | | |
| Δ wage · labor share | | | 0.257*** | 0.257*** |
| | | | (0.073) | (0.073) |
| Δ productivity | -0.0269 | -0.0270 | -0.0287 | -0.0288 |
| | (0.023) | (0.023) | (0.023) | (0.023) |
| Δ import price | | | | |
| Δ input price | 0.0463*** | 0.0463*** | 0.0470*** | 0.0470*** |
| | (0.006) | (0.006) | (0.007) | (0.007) |
| N | 1216 | 1187 | 1216 | 1187 |
| R2 | 0.647 | 0.647 | 0.645 | 0.645 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price growth to wage growth (columns 1 and 2) and to wage growth interacted with sectoral labor share (columns 3 and 4). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 2) with wage growth or an interaction between contemporaneous wage growth and labor share, two lags of price growth, two lags of wage growth or an interaction between labor share and wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Sample period is restricted to years prior to 2020. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.




(a) Services sectors

(b) Non-shelter services sectors

Figure B.9: Contemporaneous pass-through in the COVID-19 pandemic recovery

*Note:* The figures plot the contemporaneous impulse response of price growth to the interaction of wage growth with a post-COVID indicator variable. The horizontal axis represents the last quarter of data used for estimation. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The vertical black lines represent the 90% confidence interval. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.5: Pass-through in periods with high wage growth

| | Pre-COVID (2010-2019) | | All years (2010-2023) | |
|---|---|---|---|---|
| | Services | Non-shelter | Services | Non-shelter |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.0939** | 0.0939** | 0.0588 | 0.0588 |
| | (0.045) | (0.045) | (0.040) | (0.040) |
| Δ wage · high Δ wage | 0.0914* | 0.0914* | 0.136*** | 0.136*** |
| | (0.052) | (0.052) | (0.049) | (0.049) |
| Δ wage · postCOVID | | | 0.0127 | 0.0129 |
| | | | (0.036) | (0.036) |
| Δ productivity | -0.0298 | -0.0298 | 0.0396* | 0.0396* |
| | (0.023) | (0.023) | (0.021) | (0.021) |
| Δ import price | | | | |
| Δ input price | 0.0464*** | 0.0464*** | 0.0805*** | 0.0805*** |
| | (0.006) | (0.006) | (0.016) | (0.016) |
| N | 1216 | 1187 | 1648 | 1607 |
| R2 | 0.649 | 0.649 | 0.729 | 0.729 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with an indicator for high wage growth. High wage growth is defined as sector-years with wage growth above the 75th percentile. Price and wage growth are the four-quarter log changes in the PCE price index and wage, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction of wage growth with a post-COVID indicator variable (Columns 3 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.6: Pass-through accounting for supply shocks

| | Pre-COVID (2010-2019) | | All years (2010-2023) | |
|---|---|---|---|---|
| | Services | Non-shelter | Services | Non-shelter |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.0919** | 0.0919** | 0.0544 | 0.0544 |
| | (0.045) | (0.045) | (0.042) | (0.042) |
| Δ wage · postCOVID | | | -0.0397 | -0.0395 |
| | | | (0.040) | (0.040) |
| Δ wage · high Δ wage | 0.0965* | 0.0965* | 0.145*** | 0.145*** |
| | (0.056) | (0.056) | (0.048) | (0.048) |
| Δ wage · Δ input price | 0.182 | 0.182 | 0.465* | 0.466* |
| | (0.355) | (0.355) | (0.250) | (0.250) |
| Δ productivity | -0.0300 | -0.0301 | 0.0373* | 0.0373* |
| | (0.023) | (0.023) | (0.021) | (0.021) |
| Δ input price | 0.0426*** | 0.0426*** | 0.0644*** | 0.0644*** |
| | (0.009) | (0.009) | (0.014) | (0.014) |
| N | 1216 | 1187 | 1648 | 1607 |
| R2 | 0.649 | 0.649 | 0.730 | 0.730 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with import and input price growth. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction between wage inflation and a post-COVID indicator variable (Columns 3 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

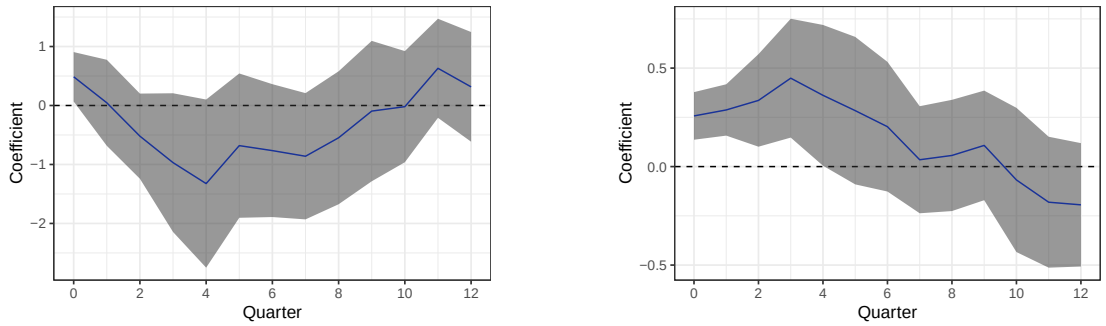
## B.4 Other results

Table B.7: Pass-through accounting for labor share, using 8 lags

| | Goods sectors | | Services sectors | |
|---|---|---|---|---|
| | w/o labor share | w/ labor share | w/o labor share | w/ labor share |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.0556 | | 0.0930** | |
| | (0.050) | | (0.043) | |
| Δ wage · labor share | | 0.328 | | 0.265*** |
| | | (0.241) | | (0.093) |
| Δ productivity | -0.00885 | -0.0122 | -0.0229 | -0.0245 |
| | (0.031) | (0.031) | (0.021) | (0.020) |
| Δ import price | 0.205*** | 0.202*** | | |
| | (0.057) | (0.058) | | |
| Δ input price | 0.187** | 0.187** | 0.0423*** | 0.0423*** |
| | (0.077) | (0.077) | (0.008) | (0.008) |
| N | 972 | 972 | 1202 | 1202 |
| R2 | 0.841 | 0.841 | 0.710 | 0.712 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price growth to wage growth (columns 1 and 3) and to wage growth interacted with sectoral labor share (columns 2 and 4). Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 2) with wage growth or an interaction between contemporaneous wage growth and labor share, eight lags of price growth, eight lags of wage growth or an interaction between labor share and wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Sample period is restricted to years prior to 2020. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.




(a) Goods sectors (b) Services sectors

Figure B.10: Impulse responses of price inflation to wage inflation, accounting for labor share

*Note:* The figures plot the estimated pass-through of wage inflation to price inflation interacted with labor share at different quarterly horizons. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation 2) with two lags of price inflation, two lags of an interaction between labor share and wage inflation, sector fixed effects, time fixed effects, and four-quarter changes in productivity, import prices and input prices as controls. Sample period is restricted to years prior to 2020. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

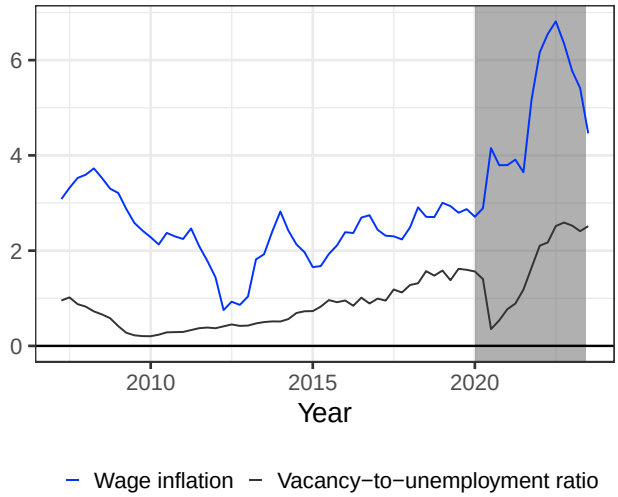



Figure B.11: Historical time series of wage growth and vacancy-to-unemployment ratios

*Note:* The figure plots the time series of average wage growth and average vacancy-to-unemployment ratio across sectors. Wage growth is the four-quarter log change and at a quarterly frequency. *Source:* BLS, BEA, and authors' calculations.

Table B.8: Pass-through in periods with high vacancy-to-unemployment ratios

| | Pre-COVID (2010-2019) | | All years (2010-2023) | |
|---|---|---|---|---|
| | Goods | Services | Goods | Services |
| | (1) | (2) | (3) | (4) |
| Δ wage | 0.118 | 0.154*** | 0.130** | 0.0984*** |
| | (0.071) | (0.031) | (0.059) | (0.034) |
| Δ wage · high v/u | -0.181 | -0.134*** | -0.0796 | -0.0588* |
| | (0.129) | (0.048) | (0.250) | (0.029) |
| Δ wage · postCOVID | | | 0.0182 | 0.106*** |
| | | | (0.319) | (0.026) |
| Δ productivity | -0.0892 | -0.0196 | -0.141** | 0.0410** |
| | (0.057) | (0.025) | (0.053) | (0.017) |
| Δ import price | 0.150** | | 0.0991 | |
| | (0.062) | | (0.063) | |
| Δ input price | 0.418*** | 0.0486*** | 0.511*** | 0.103*** |
| | (0.076) | (0.014) | (0.061) | (0.031) |
| N | 631 | 1074 | 883 | 1458 |
| R2 | 0.867 | 0.631 | 0.879 | 0.710 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with an indicator for a high vacancy-to-unemployment ratio. High vacancy-to-unemployment ratio is defined as sector-years with a vacancy-to-unemployment ratio above the 75th percentile. Price and wage growth are the four-quarter log changes in the PCE price index and wage, respectively, and at a quarterly frequency. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction of wage growth with a post-COVID indicator variable (Columns 3 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.9: Pass-through accounting for supply shocks, replication of Amiti et al. (2022)

| | Goods (1) | Goods (2) | Services (3) | Services (4) |
|---|---|---|---|---|
| Δ wage | 0.0585 | -0.0225 | 0.0947*** | 0.0958*** |
| | (0.064) | (0.100) | (0.028) | (0.028) |
| Δ wage · postCOVID | 0.130 | 1.389*** | 0.0693*** | 0.0420 |
| | (0.140) | (0.206) | (0.020) | (0.069) |
| Δ import price | 0.250*** | 0.346*** | | |
| | (0.062) | (0.085) | | |
| Δ import price · postCOVID | -0.218*** | -0.162 | | |
| | (0.058) | (0.137) | | |
| Δ input price | 0.244*** | 0.0846 | 0.0638*** | 0.0576*** |
| | (0.074) | (0.114) | (0.018) | (0.016) |
| Δ input price · postCOVID | 0.273*** | 0.866*** | 0.0530** | 0.0474* |
| | (0.099) | (0.177) | (0.026) | (0.028) |
| Δ wage · Δ import price | | -4.227** | | |
| | | (2.095) | | |
| Δ wage · Δ import price · postCOVID | | -1.158 | | |
| | | (2.730) | | |
| Δ wage · Δ input price | | 6.175* | | 0.260 |
| | | (3.322) | | (0.276) |
| Δ wage · Δ input price · postCOVID | | -16.98*** | | 0.0113 |
| | | (3.904) | | (0.834) |
| Δ productivity | -0.0161 | -0.0497 | 0.0463** | 0.0447** |
| | (0.037) | (0.031) | (0.020) | (0.020) |
| N | 1219 | 1219 | 1468 | 1468 |
| R2 | 0.813 | 0.829 | 0.651 | 0.651 |

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

*Note:* The table presents estimates of the contemporaneous impulse response of price inflation to the interaction of wage inflation with import and input price growth. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. Sample period is restricted to 2010-2021Q3. *Estimation method:* Contemporaneous pass-through specification (Equation 3) with the interaction between wage inflation a post-COVID indicator variable, the interaction between import or input price growth and a post-COVID indicator variable, the interaction between wage inflation and import or input price growth and a post-COVID indicator variable (Columns 2 and 4), two lags of price growth, two lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

## B.5 Interpreting the pass-through coefficient

### B.5.1 Pass-through of prices to wages

To estimate the impulse response of wage inflation to price inflation at the metropolitan area-level, we estimate the following specification for each month $h = 0, \ldots, 24$:

$$\begin{aligned}\Delta \ln(w_{i,t+h}) = \alpha + \beta_h \Delta \ln(p_{i,t}) + \sum_{j=1}^{24} \delta_j \Delta \ln(w_{i,t-j}) + \sum_{j=1}^{24} \zeta_j \Delta \ln(p_{i,t-j}) \\ + \gamma \mathbf{X}_{it} + \xi_i + \rho_t + \varepsilon_{it}\end{aligned} \tag{B.1}$$

where for metropolitan area $i$ and month $t$, $\Delta \ln(w_{i,t+h})$ is the annual change in wages in month $t+h$, $\Delta \ln(p_{i,t-j})$ is the annual change in prices in month $t-j$, $\mathbf{X}_{it}$ is a vector of controls (the unemployment gap, union coverage, share of part-time workers, share of self-employed workers, and share of workers who are paid hourly), $\xi_i$ is a metropolitan area fixed effect, and $\rho_t$ is a time fixed effect. The coefficient of interest, $\beta_h$, measures the feedback from price growth in month $t$ to wage growth in month $t+h$. The regression is weighted by a metropolitan area's total employment. We use Driscoll-Kraay standard errors with a lag of four months. Equation B.1 is estimated using data for 22 metropolitan areas between 2008-2022.

### B.5.2 Instrumenting for wage growth

We use job-to-job transition rates to isolate the inflationary component of wage growth that comes from competition among employers, as in Karahan et al. (2017) and Moscarini and Postel-Vinay (2017). The exclusion restriction is that competition among employers for workers does not affect prices directly, but only through firms' responses to increased labor costs. The first-stage estimates show that job-to-job transition rates predict wage growth well in services sectors (F-stat

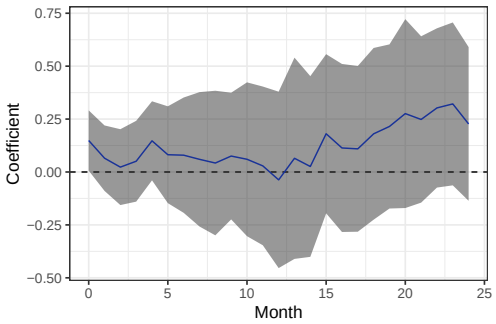



Figure B.12: Impulse response of nominal wage growth to inflation

*Note:* The figure plots the estimated pass-through of price inflation to wage inflation at different monthly horizons. Price and wage growth are annualized and at a monthly frequency. The gray ribbon represents the 90% confidence interval. *Estimation method:* Local projection specification (Equation B.1) with lagged wage growth, lagged inflation, unemployment gap, union coverage, share of part-time workers, share of self-employed workers, share of workers who are paid hourly, sector fixed effects, and time fixed effects as controls. Each observation is weighted by each metropolitan area's number of employed workers. Standard errors are Driscoll-Kraay standard errors with a bandwidth of five months. *Source:* BLS, BEA, and authors' calculations.

= 12.33) but not in goods sectors (F-stat = 0.449). The second-stage regression shows a pass-through of 33.2 percent ($p = 0.029$) for services sectors, consistent with the positive pass-through estimated in our local projection estimates. On the other hand, the instrumental variable estimate is higher than the contemporaneous pass-through estimated in the local projection estimates, 11.5 percent, suggesting that the local projection estimates may be downward biased, which would not be the case if there was a feedback from current inflation into wage growth.

We also estimate the instrumental variable regressions restricting to the period before the COVID-19 pandemic. The first-stage regressions are weak for both goods sectors (F-stat = 1.678) and services sectors (F-stat = 7.847).

Table B.10: Impulse responses of price inflation to wage inflation, instrumental variable regressions

| | Goods sectors | | Services sectors | |
|---|---|---|---|---|
| | Δ wage | Δ price | Δ wage | Δ price |
| | (1) | (2) | (3) | (4) |
| J2J | -0.477 | | 0.935*** | |
| | (0.712) | | (0.266) | |
| Δ wage | | -3.838 | | 0.332** |
| | | (7.563) | | (0.147) |
| Δ productivity | -0.0940*** | -0.402 | 0.0190 | 0.0356* |
| | (0.027) | (0.662) | (0.013) | (0.019) |
| Δ input price | -0.0182* | 0.194 | -0.00589 | 0.0655*** |
| | (0.011) | (0.186) | (0.007) | (0.014) |
| N | 1251 | 1251 | 1522 | 1522 |
| F-Statistic | 0.449 | | 12.33 | |

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

*Note:* The table presents results of the first-stage regression of wage growth on job-to-job transition rates (Columns 1 and 3) and the second-stage regression of the contemporaneous impulse response of price growth to instrumented wage growth (Columns 2 and 4). Job-to-job transition rate is from the Longitudinal Employer-Household Dynamics. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. *Estimation method:* Local projection specification (Equation 1) with $h = 0$ and eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

Table B.11: Impulse responses of price inflation to wage inflation, instrumental variable regressions, restricting to years prior to the COVID-19 pandemic

| | Goods sectors | | Services sectors | |
|---|---|---|---|---|
| | Δ wage | Δ price | Δ wage | Δ price |
| | (1) | (2) | (3) | (4) |
| J2J | 0.810 | | 0.546*** | |
| | (0.625) | | (0.195) | |
| Δ wage | | 3.907 | | -0.0705 |
| | | (2.873) | | (0.405) |
| Δ productivity | -0.0891*** | 0.339 | 0.0315 | -0.0176 |
| | (0.023) | (0.300) | (0.020) | (0.024) |
| Δ input price | -0.0340*** | 0.319** | 0.00118 | 0.0420*** |
| | (0.012) | (0.126) | (0.007) | (0.008) |
| N | 972 | 972 | 1202 | 1202 |
| F-Statistic | 1.678 | | 7.847 | |

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

*Note:* The table presents results of the first-stage regression of wage growth on job-to-job transition rates (Columns 1 and 3) and the second-stage regression of the contemporaneous impulse response of price growth to instrumented wage growth (Columns 2 and 4). Job-to-job transition rate is from the Longitudinal Employer-Household Dynamics. Price and wage growth are the four-quarter log changes in the PCE price index and wages, respectively, and at a quarterly frequency. Sample period is restricted to 2010-2019. *Estimation method:* Local projection specification (Equation 1) with $h = 0$ and eight lags of price growth, eight lags of wage growth, sector fixed effects, time fixed effects, and four-quarter log changes in productivity, import prices and input prices as controls. Each observation is weighted by each sector's weight in the nominal PCE. Standard errors are Driscoll-Kraay standard errors with a bandwidth of two quarters. *Source:* BLS, BEA, and authors' calculations.

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