The Missing Inflation Puzzle: The Role of the Wage-Price Pass-Through*

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January 15, 2020

Abstract

This paper revisits the growing disconnect between unemployment and inflation dynamics. First, we propose a novel and simple measure of labor market recovery—the unemployment recovery gap—and show that inflation-unemployment dynamics changed substantially in the 1990s. We then use rich industry-level data to examine the missing inflation puzzle and show that weakening pass-through from wages to prices in the goods-producing sector is an important source of the slow inflation pick-up since 1990. We identify increased import competition as a potential driver of the missing goods inflation following the Great Recession and provide empirical evidence for this channel. International evidence further confirms our hypothesis.

Keywords: Inflation dynamics, Phillips curve, pass-through, import competition
JEL Classification: E24, E31

*We are very grateful to David Dam and Meghana Gaur for superb research assistance. We would like to thank Giuseppe Moscarini for many insightful comments and suggestions on an earlier version. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.
1 Introduction

More than a decade after the end of the Great Recession, price inflation in the U.S. still remains sluggish and below the Federal Reserve’s inflation target of 2%. The behavior of price inflation is considered puzzling by many policymakers and academics given that the unemployment rate stood at 3.5% at the end of 2019—its lowest level in almost half a century.\(^1\) This paper revisits the link between the unemployment rate and inflation. First, we propose a novel and simple measure of labor market recovery—the unemployment recovery gap—and show that inflation-unemployment dynamics changed substantially in the 1990s even after accounting for the rise of jobless recoveries. We then use rich industry-level data to document that declining pass-through from wages to prices in the goods-producing sector is an important source of the slow inflation pick-up since 1990. We attribute this decline to increased import competition, and show that this channel accounts for around half of the missing inflation relative to the expansion in the 1980s.

The left panel of Figure 1 shows the evolution of the cumulative consumer price index (CPI) in the U.S. starting from the business cycle trough for each of the past five recessions. As the figure shows, each recovery is associated with a lower cumulative consumer price inflation compared to the previous one, with cumulative CPI increasing by 25% in the first 20 quarters of the recovery following the 1981-82 recession, by 15% following the 1990-91 recession, and by less than 10% in the last expansion.

While the evolution of consumer price inflation over time is informative, the duration of expansions is an increasingly misleading indicator of labor market recovery given the emergence of jobless recoveries. We therefore propose a novel measure of labor market recovery that is consistent across expansions—*the unemployment recovery gap*—and consider the evolution of price inflation with respect to this new measure. Our new metric computes the share of the rise in the unemployment rate during the preceding recession that has been reversed during the current expansion. An unemployment recovery gap of 100% thus implies that the unemployment rate has declined back to its pre-recession trough.\(^2\) In the right panel of Figure 1, we plot the evolution of cumulative CPI inflation relative to this new metric. The 1970s and the early 1980s clearly stand out as expansionary periods with inflation picking up

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\(^1\)NY Times Upshot: Janet Yellen and the Case of the Missing Inflation, June 14, 2017; Living Life Near the ZLB, John C. Williams, Remarks at 2019 Annual Meeting of the Central Bank Research Association (CEBRA), New York City, July 18, 2019.

\(^2\)There are alternative measures of labor market utilization that capture wage-growth better than the unemployment rate such as the NEI developed by Hornstein et al. (2014), the tightness measure developed in Moscarini and Postel-Vinay (2017a) and the aggregate hours gap in Faberman (2019). These alternative measures of labor market utilization typically start in 1994 due to CPS redesign. We focus on the unemployment recovery gap measure due to its simplicity and availability of a longer time series.
rapidly after the end of the recessions. The three most recent expansions exhibit a milder rise in cumulative inflation. Thus, even taking into account the emergence of jobless recoveries, the behavior of inflation changed considerably after 1990.

What is the source of this missing inflation? We analyze the behavior of core goods inflation and core services inflation separately and identify core goods inflation as the main driver of the change in inflation dynamics. We show that while core goods prices rose by about 20% as unemployment fell from recessionary peak to trough following the 1982 Recession, it barely rose after the Great Recession. At the same time, the recovery of core services inflation has been roughly similar in all expansions. We document a similar pattern also in Canada, in the Eurozone and in the U.K., with core goods inflation not picking up despite tightening labor markets.

To assess the importance of the lack of goods inflation for aggregate inflation dynamics, we compute the counterfactual cumulative inflation that would have prevailed had goods prices behaved in the same way as they did following the 1981-82 recession. We find that around 50% of the missing inflation relative to the 1980s expansion can be traced to goods prices. Interestingly, our empirical analysis shows that the change in inflation dynamics is not driven by the differential behavior of wages or productivity once the unemployment recovery gap is used to measure the extent of the recovery in the labor market. These findings suggest that the changing pass-through from wage changes to price changes is a promising explanation for the missing core goods inflation.

Our paper focuses on this novel insight and examines the link between unemployment, wages, and prices using detailed industry-level data from various data sources. We estimate
how producer prices respond to wage growth across industries focusing on the manufacturing sector as a proxy for the goods-producing sector. We find that there is essentially no pass-through from wages to producer prices in manufacturing, while we estimate a pass-through of about 20% in services using an OLS estimation, implying that a 10% increase in labor costs is associated with a 2.0% increase in service prices.

An important caveat for interpreting the OLS pass-through coefficients is that the source of the wage growth could reflect improvements in productivity. In that case, wage growth does not constitute a cost-push shock for firms and therefore does not need to pass through to prices. We address this concern using two approaches. First, we control for productivity and find that including this control does not change our main finding. Second, we consider an instrumental-variables approach.

The instrument we choose is the job-to-job transitions rate. This choice builds on the insights in Moscarini and Postel-Vinay (2017a), who show using a job-ladder model that inflationary wage growth arises when firms try to poach employees of other firms, since poachers bid up the wages of employed workers and incumbents raise wages to increase retention. We build on the empirical work of Karahan et al. (2017) and Moscarini and Postel-Vinay (2017b), and use the realized job-to-job transitions as instrument. The exclusion restriction behind this instrument is that the competition between workers does not affect prices directly, for example by affecting firms’ productivity; wages are affected due to competition and prices only due to increasing unit labor costs. We find that pass-through in manufacturing is still negligible. Instead, we still find significant positive pass-through for services.

We exploit the availability of a longer time series in manufacturing to document that the pass-through from wages to prices in that sector has steadily declined over the last three decades. While pass-through was positive and significant until the early 2000s, it has been essentially zero since then.

In the last section of the paper, we propose increasing import competition as the driver of lack of pass-through from wages to prices in manufacturing. As often discussed in the literature, rising import competition decreases firms’ pricing power and therefore reduces pass-through from cost-push shocks to prices. We find strong empirical support for this hypothesis: industries that are exposed to more competition from abroad exhibit lower wage-price pass-through. As import penetration has risen significantly over the last decades, pass-through in manufacturing overall has declined. This finding adds to an earlier literature showing that rising import penetration has also led to a decline in manufacturing employment.

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3 A long-standing literature addresses the various conceptual and econometric difficulties of pass-through regressions more generally, mostly in the context of exchange-rate pass-through. See for example, Campa and Goldberg (2005) and Nakamura and Zerom (2010).
Our paper is closely related to the recent literature examining the puzzling inflation dynamics during and after the Great recession. Del Negro et al. (2015), Carvalho et al. (2017), Coibion and Gorodnichenko (2015), and Coibion et al. (2019) all emphasize the role of inflation expectations in accounting for the behavior of inflation. Our analysis complements these papers by uncovering an additional channel for subdued inflation that only affected core goods inflation.

The rest of the paper is organized as follows. Section 2 discusses the data. Section 3 defines our measure of labor market recovery and establishes the aggregate facts regarding the post-recession behavior of inflation, wages and productivity. Section 4 estimates the pass-through of wages to prices in manufacturing and services and investigates the effect of import competition. Finally, Section 5 concludes.

2 Data

Our motivating facts are based on aggregate price and wage data from the Bureau of Labor Statistics (BLS). First, we obtain the quarterly, seasonally adjusted Consumer Price Index (CPI-U) for goods excluding food and energy and for services excluding energy services. Second, we use the average hourly earnings of production and non-supervisory employees, seasonally adjusted, both for the goods-producing and the services-providing sector. To analyze how these series relate to the state of the economy, we obtain from the BLS the quarterly, seasonally adjusted unemployment rate of workers 16 years and older, and retrieve from the Bureau of Economic Analysis (BEA) the seasonally adjusted, real gross domestic product.

Our analysis of the pass-through from wages to prices combines several publicly available datasets. For the price data, we use the industry-level Producer Price Index (PPI) series from the BLS. The PPI collects the average monthly selling prices for domestically produced goods and services at various levels of industry disaggregation. Indices for most manufacturing industries go back to the 1980s, while comprehensive coverage for most service industries does not begin until the early 2000s. The PPI accounts for the near universe of output in the goods-producing sector and approximately three-quarters of the output in the service-providing sector. We obtain all available series, reported at most at the 6-digit NAICS code level, and fill in missing observations using linear interpolation if data are missing for fewer than three consecutive months. We do not impute values when data for an industry are missing for three or more consecutive months.

Since some NAICS codes change over time or are aggregated differently, we construct
time-consistent NAICS codes using the list of NAICS revisions from 1997 to 2017 provided by the U.S. Census Bureau. We splice together NAICS codes referring to the same industry when the industry’s code changes, and combine disaggregated codes into one if only a more aggregated code exists at some point in the data. This aggregation is performed by taking a weighted average over the changes in the industry-level PPI series involved, using total shipments from the Economic Census in 2002 as weight. We remove seasonality from the PPI series using the Census’ X-12-ARIMA Seasonal Adjustment program, and aggregate the price indices to the quarterly frequency by taking the three-month averages. We exclude mining and utilities from all analyses since prices in the former is driven mostly by commodity prices while in the latter prices are subject to regulation.

For wages, we obtain earnings data from the Quarterly Census of Employment and Wages (QCEW) from the BLS. The QCEW reports the number of establishments, monthly employment, and quarterly total payrolls for workers covered by State unemployment insurance (UI) laws and Federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. Overall, the data cover more than 95 percent of U.S. jobs. The QCEW data are collected by state agencies and reported to the BLS, and represent the total compensation paid during the calendar quarter, including bonuses, stock options, severance pay, and so on for most states. We use national-level data by NAICS industry, and construct an average quarterly wage for each industry by dividing the industry’s total quarterly payroll by its number of workers. For most industries, the data cover the period from 1990 to 2018. We create time-consistent NAICS codes using the same mapping as before by summing over the industry-level total payroll and number of workers of the industries involved, and seasonally adjust the data.

Our baseline pass-through dataset combines the price and the wage data at the 4-digit NAICS level, and at more detailed levels when both price and wage information are consistently available. In total, we have information for 139 disaggregated NAICS industries, of which 53 are in manufacturing. The first available year where we have price information for goods and services is 2003. We perform further analysis for the manufacturing sector alone going back to 1993.

We merge into our baseline dataset information on industry productivity, using estimates of multifactor productivity (MFP) from the BLS. For the manufacturing sector, the BLS provides annual MFP estimates at the four digit NAICS level, and at greater disaggregation for some industries. The data are available for the 1987-2016 period. Whenever MFP is missing for an industry at a given aggregation level, we use the finest higher level of aggregation available. For non-manufacturing industries, the BLS does not provide productivity estimates with the same level of granularity. For these industries, we therefore use MFP measures at
the two or three digit NAICS level from the Integrated Industry-Level Production Account (KLEMS) tables provided by the BLS, and use for each industry the productivity value at the next available higher level of aggregation. Since the productivity data end in 2016, our final dataset for both goods and services spans the period from 2003-2016, and for the manufacturing sector alone from 1993-2016.

We construct several additional controls. We obtain quarterly employment by gender, education, and age from the Quarterly Workforce Indicators (QWI) at the four digit NAICS and three digit NAICS levels from 1990 to 2018. For each industry and quarter, we compute the share of male and female workers, as well as the share of high-skilled and medium-skilled workers, defined by those who have a Bachelor’s degree or higher, and those who have a high school or equivalent degree (no college), respectively. We generate the shares of young, middle-aged, and older workers by defining young workers as those aged below 24 years, middle-aged as those 25-54, and older as those 55 and older. For industries that are more disaggregated than the four digit level, we use the finest higher level of aggregation available.

3 Aggregate Facts

We begin our analysis by showing that the slower recovery of the CPI following a recession in the recent period is largely attributable to the changing behavior of goods prices. The behavior of prices for services is largely unchanged from the earlier periods. International evidence paints a similar picture. We do not find evidence for changing wage inflation or productivity in explaining the behavior of goods inflation.

3.1 Evidence on Inflation in the U.S.

Our comparison of inflation across different recessions needs to take into account that the recent recoveries have been more and more "jobless" (see, for example, Jaimovich and Siu (2012) or Galí et al. (2012)). In other words, inflation may have been slow to pick up in more recent recessions simply because the labor market is now taking longer to recover. We therefore propose a novel measure of labor market recovery that is consistent across expansions—the unemployment recovery gap—and consider the evolution of price inflation with respect to this new measure. Our new metric computes the share of the rise in the unemployment rate during the preceding recession that has been eliminated during the current expansion. Specifically, for each recession, we find the peak quarterly unemployment rate, $u_{peak}$, from the seasonally adjusted unemployment rate of workers 16 years and older, and
compute the recovery of unemployment back to its pre-recession trough as

$$U_{Recovery_t} = \frac{u_{peak} - u_t}{u_{peak} - u_{trough}},$$  \hspace{1cm} (1)$$

where $u_{trough}$ is the unemployment rate at the pre-recession trough and $u_t$ is current unemployment. A value of 0.5 thus indicates that the unemployment rate has recovered 50% of its increase in the preceding recession. The emergence of jobless recoveries implies that any given value of $U_{Recovery_t}$ takes longer to achieve in recent episodes. Our new measure introduces both history dependence and changing output-employment dynamics, and is simple and easy to track.

Our analysis focuses on cumulative price growth rather than on monthly inflation. Both goods and services inflation are volatile on a monthly basis as they are affected continuously by transitory factors. By focusing on a cumulative measure, we are able to average out these fluctuations. In what follows, we compare the cumulative growth in consumer prices (CPI-U core inflation) since the previous recession’s peak unemployment, overall and separately for core goods and for core services, against the recovery in the labor market ($U_{Recovery}$) for the expansions following the past four recessions.\(^4\)

Figure 2 establishes our first fact: Growth in core goods prices has slowed remarkably over time and accounts for a large share of the weakening inflation over time. While core goods prices rose by about 20% as unemployment fell from peak to trough following the 1982 recession (Figure 2a), after the 2009 recession core goods prices barely rose (Figure 2d). At the same time, the recovery of core services inflation has been roughly similar in all expansions.

To show that this finding is not driven by our measure of recovery, we construct analogous sets of figures for two alternative measures in Appendix A. Figure A.1 shows the cumulative price growth against the cumulative GDP growth since peak unemployment and Figure A.2 plots price growth against time since peak unemployment. Both figures paint a similar picture as our baseline in Figure 2.

To what extent can the weakening inflation dynamics in the goods sector explain the weak inflation following the current expansion? To quantify the size of this effect, we compute the counterfactual (cumulative) inflation that would have prevailed had goods prices behaved in the same way as they did following the 1982 recession. Specifically, we take the core goods CPI from that episode and the core CPI in services from the current expansion and compute an overall CPI using the current weights. Figure 3 shows that around 50% of the

\(^4\)Core goods inflation is for all goods excluding food and energy. Core services inflation is for all services excluding energy services.
weakening of inflation relative to the 1982 episode can be traced to goods prices. This finding implies that one needs to understand why the behavior of goods prices changed over time to understand a significant part of the weakness in current inflation.

In a competitive market, firms’ prices are determined by the costs of their inputs and productivity. If either costs have been rising more slowly or if productivity has been rising more rapidly for goods in the most recent recoveries, then this could explain the weakness of goods price inflation. We next show that wage growth in the goods sector has been similar in the past four recessions, and that productivity has in fact been weaker in goods-producing industries recently.
Wages
Cumulative inflation can be weaker for goods prices simply because labor costs in goods-producing industries, particularly in the recent expansions, did not increase as much as they did in service-providing industries. To analyze this possibility, we construct figures analogous to Figure 4 for wage inflation, where wages are measured as hourly earnings of production workers. We obtain these data for goods-producing industries and for services-providing industries, respectively. Figure 4 highlights that wages behaved in the same way in both sectors across all four recessions. In particular, the data do not show a slowdown in wage growth in the goods-producing sector. Figures A.3 and A.4 in the Appendix show similar patterns when we plot wage inflation against GDP growth and time, respectively.

Productivity
A given level of wage growth could be more or less inflationary depending on productivity growth. For example, if productivity in goods-producing sectors grew faster than in services, then this would imply more slowly rising unit labor costs in goods compared to services despite similar nominal wage growth. We therefore investigate if the changing price dynamics are driven by differences in productivity growth. From the BLS’s multifactor productivity data collected in the KLEMS tables, we obtain an annual productivity estimate for the manufacturing sector overall. We interpret this sector as the goods-producing part of the economy. For services, we combine from the KLEMS table the productivity series for retail and wholesale trade, transportation and warehousing, information, and finance, insurance,
Figure 5 shows the two resulting series. The figure shows that, if anything, in the recent period productivity grew faster in services than in manufacturing. Cumulative TFP growth was stronger in manufacturing following the 1982 recession, on par with services following the 2003 recession, and weaker following the Great Recession.

To summarize, our analysis based on aggregate data shows that the changing behavior of CPI is attributable weak inflation in goods producing sectors. The latter is not driven by the differential behavior of wages or productivity. It therefore seems that the culprit is the pass-through from wage changes to price changes, which must have weakened in the goods-producing sector, but not in services. We examine this conjecture in the next section.
Figure 5: Productivity Growth from Three Previous Recessions

(a) 1992 Recession

(b) 2003 Recession

(c) 2010 Recession

using detailed industry data.

3.2 International evidence

Did other countries observe shifts in the post-recession behavior of inflation similar to the United States? Inflation data from several other countries paints a similar picture. We analyze data from Canada, the U.K., and the Euro zone. Overall, we find a similar pattern with inflation in the goods sector being significantly smaller than in services.\(^5\)

\(^5\)See Figure A.5 for Canada, Figure A.6 for the UK, and Figure A.7 for the Euro zone, respectively.
4 Pass-Through from Wages to Prices

Our analysis of aggregate data suggest that weakening inflation in the goods-producing sector can be traced to a decline in the pass through of increases in labor costs to prices. In this section we estimate measures of this pass-through in the goods and service producing industries, and confirm the hypothesis of declining pass-through from wages to prices in goods-producing industries.

4.1 Pass-Through in the Goods- and Services-Providing Industries

Our empirical analysis compares the changes in prices in response to wage growth across industries, using our baseline dataset. We use the manufacturing sector as a proxy for goods-producing industries, since we have a long and consistent time series for this sector. Manufacturing accounted for about 63% of employment in goods-producing industries in the last decade.

We estimate specifications of the form

$$\Delta \ln(p_{it}) = \beta \Delta \ln(w_{it}) + \gamma X_{it} + \delta_i + \rho_t + \epsilon_{it},$$

where $p_{it}$ is the producer price index in industry $i$ and period $t$, $X_{it}$ is a set of time-varying controls for the composition of the workforce of industry $i$, $\delta_i$ are industry fixed effects, and $\rho_t$ are time fixed effects. The industry controls include the share of female workers in the industry, the share of workers with at least high-school education, the share of workers with some college, and the share of workers with at least a Bachelor’s degree (the omitted category is workers without a high-school degree), and the share of middle-aged and older workers. The coefficient $\beta$ captures the pass-through of wage changes to price changes and is identified by comparing how much of a higher wage growth in one sector relative to the others translates into a higher growth in producer prices in that sector. We are interested in how $\beta$ varies across sectors and over time.

To implement equation (2), we use our baseline quarterly dataset covering the period 2003–2016, and compute the four quarter (log) change in each industry’s producer price index, $\Delta \ln(p_{it})$. We compute four quarter log change in wages, $\Delta \ln(w_{it})$, analogous to the change in prices. All regressions are weighted by an industry’s total sales in 2012.

Table 1 presents the results from our baseline regression. Column (1) starts with a simple specification and shows that the pass-through from wage changes to price changes is

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6Note that while we are interested in understanding consumer prices, we analyze producer prices in this section given the high correlation in aggregate data between producer and consumer prices.
Table 1: Pass-Through Regressions for Goods versus Services

<table>
<thead>
<tr>
<th></th>
<th>Baseline Regression</th>
<th>Wage × Labor Share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aggregate</td>
<td>No TFP</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>ΔWage</td>
<td>0.0821***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0196)</td>
<td></td>
</tr>
<tr>
<td>ΔWage Manufacturing</td>
<td>-0.0135</td>
<td>0.0101</td>
</tr>
<tr>
<td></td>
<td>(0.0315)</td>
<td>(0.0316)</td>
</tr>
<tr>
<td>ΔWage Services</td>
<td>0.127***</td>
<td>0.112***</td>
</tr>
<tr>
<td></td>
<td>(0.0228)</td>
<td>(0.0228)</td>
</tr>
<tr>
<td>ΔTFP</td>
<td></td>
<td>-0.0967***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0138)</td>
</tr>
<tr>
<td>ΔWage × LS Manufacturing</td>
<td></td>
<td>-0.195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.2467)</td>
</tr>
<tr>
<td>ΔWage × LS Services</td>
<td>0.259***</td>
<td>0.197***</td>
</tr>
<tr>
<td></td>
<td>(0.0858)</td>
<td>(0.0859)</td>
</tr>
<tr>
<td>Time Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R-Sq.</td>
<td>0.118</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>0.117</td>
<td>0.124</td>
</tr>
<tr>
<td>N</td>
<td>6,306</td>
<td>6,306</td>
</tr>
<tr>
<td></td>
<td>6,306</td>
<td>6,306</td>
</tr>
</tbody>
</table>

TFP is total factor productivity. LS refers to the labor share. All regressions are weighted by an industry’s sales in 2012.

about 0.08. However, this result masks considerable heterogeneity across goods and services. Column (2) includes in the regression separately a coefficient for the wage change in the manufacturing sector and in services, respectively. These terms are computed as $\Delta \ln(w_{it})$ times a dummy for whether the industry is a manufacturing or a service industry. We find that the correlation between wage changes and price changes is insignificant in the manufacturing sector, both economically and statistically, and about 0.13 in services. Thus, the positive relationship between wage changes and price changes found in the aggregate appears to be due to the services sector alone.

Clearly, the interpretation of the pass-through coefficient is subject to several concerns. One particularly important caveat is regarding the underlying source of wage growth. Empirical and theoretical work has established that demand-driven wage growth can be inflationary, whereas productivity-driven wage growth is not. If wage growth reflects improvements in TFP, if anything, it can be deflationary. To what extent do the results in columns (2) and
To investigate this possibility in driving our results, in Column (3), we additionally control for the four quarter change in industry $i$’s TFP. As expected, an increase in productivity has a strongly negative effect on price changes. A 10% increase in productivity translates to a 1% decline in wage growth. Importantly, the pass-through of price changes to wage changes is relatively unchanged when controlling for productivity. While statistically insignificant, the fact that the coefficient for manufacturing turns slightly positive indicates that some of the low pass-through in this sector may have been due to improvements in productivity.

Another concern is related to the measure of labor costs. Wage growth represents an increase in labor costs to firms only to the extent that labor is used in firms operating in that industry. In fact, in competitive models where the pass-through is complete (i.e. equal to one), wage changes translate to a price change in an industry that is equal to the industry’s share of labor in total output. Through this lens, the lower pass-through rates estimated for manufacturing in Columns (1)–(3) might be due to differences in labor’s share in output across industries rather than due to differences in pricing behavior. Moreover, given the large heterogeneity in the share of labor across industries, using a raw measure of wages might bias the results.

To get at these concerns, we replace wage growth with the interaction of wage growth with the industry’s labor share (with and without controlling for TFP, respectively). For manufacturing, we calculate the labor share in each industry as the industry’s payroll divided by its total shipments in a given year based on the Annual Survey of Manufacturers (ASM) from 1997-2016. We use the data from 1997 in earlier years, and the data from 2016 in later years. For non-manufacturing industries, we calculate the labor share as total payroll divided by sales from the censuses in 2002, 2007, and 2012, and assume that the labor shares remain constant until a new data release is available. In the years prior to 2002, we use the 2002 labor share.

The results presented in Columns (4) and (5) corroborate our earlier interpretation and strengthen the magnitudes. Specifically, we estimate a pass-through between 20% in services (when controlling for productivity), implying that a 10% increase in labor costs is associated with a 2.0% increase in service prices. The pass-through in manufacturing is still estimated to be zero.

**Job-to-Job Transitions as an Instrument**

As we discussed before, wage growth can be driven by a host of factors such as changes in worker composition, improvements in labor productivity, and increases in labor demand. Clearly, the way firms adjust their prices in response to these factors can be quite different
depending on the source. Given our focus on inflation, we need to isolate the inflationary component of wage growth and measure the response of prices to that part of wage growth.

To do so, we build on the insights in Moscarini and Postel-Vinay (2017a) who show using a job ladder model embedded in a New Keynesian framework that inflationary wage growth occurs when it represents competitive pressures in hiring and retention. Such pressure materializes when firms try to poach employees of other firms, which leads the poachers to bid up the wages of employed workers and incumbent firms raising their wages to increase retention. Wage growth due to such a mechanism is inflationary precisely because it raises wages for people without raising their productivity.

To implement this idea and isolate the wage growth due to competition between employers, we build on empirical work in Karahan et al. (2017) and Moscarini and Postel-Vinay (2017b). These papers show that when the frequency of job-to-job transitions increases, wage growth accelerates more than it does in response to improvements in the job finding rate for the unemployed, consistent with a large class of job ladder models such as Burdett and Mortensen (1998) and Postel-Vinay and Robin (2002). We use the realized job-to-job transitions to instrument for wage growth. In other words, controlling for productivity, the variation in wage growth predicted by job-to-job transitions is the inflationary component of wage growth. The exclusion restriction behind this instrument is that the competition between workers does not affect firms’ pricing decisions directly; rather, wages are affected due to competition and prices change only in response to increasing unit labor costs.

We construct the instrument using publicly available, quarterly job-to-job transition rates from the Longitudinal Employer Household-Dynamics (LEHD). The publicly available LEHD data provide job-to-job transition rates at the two-digit sector level, separately by gender and education level, since 2000. Using this information, we impute the job-to-job transition rate for each of the disaggregated industries in our sample (4-digit or more) as a weighted average over the job-to-job transition rates by gender and education within the associated two-digit sector, using the gender and education shares of workers in our disaggregated industry as weights. The instrument therefore picks up time variation in job-to-job transitions for the aggregate sector level and in the composition of workers in a given industry. We expect the instrument to perform particularly poorly in manufacturing, since the LEHD treats manufacturing as a single sector. We smooth out noise over time by using a moving average of a given quarter’s job-to-job transition rate and its three lags.

We estimate the baseline specification in (2) instrumenting wage changes with the job-to-job transition rates in each industry. Table 2 presents our results. In Column (1), we instrument for services only, and find significant and positive pass-through in both services.
Table 2: IV Regressions Using Job-to-Job Transitions

<table>
<thead>
<tr>
<th></th>
<th>IV Regressions</th>
<th>First Stage Regressions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Services Only</td>
<td>(2) Instruments for Both</td>
</tr>
<tr>
<td>∆Wage Services</td>
<td>1.099*** (0.3775)</td>
<td>1.318** (0.5501)</td>
</tr>
<tr>
<td>∆Wage Manufacturing</td>
<td>0.199*** (0.0742)</td>
<td>-0.479 (1.5236)</td>
</tr>
<tr>
<td>∆TFP</td>
<td>-0.0685*** (0.0204)</td>
<td>-0.0177 (0.1118)</td>
</tr>
<tr>
<td>∆J2J Manufacturing</td>
<td></td>
<td>0.393* (0.2352)</td>
</tr>
<tr>
<td>∆J2J Services</td>
<td></td>
<td>0.795*** (0.1601)</td>
</tr>
<tr>
<td>Time Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R-Sq.</td>
<td>-0.286</td>
<td>-0.496</td>
</tr>
<tr>
<td>N</td>
<td>6306</td>
<td>6306</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>16.26</td>
<td>3.801</td>
</tr>
</tbody>
</table>

First-Stage regressions correspond to Column (2).
TFP is total factor productivity.
J2J refers to job-to-job transition rates.

and the (not instrumented) manufacturing. However, pass-through in manufacturing becomes negative and insignificant once we also instrument for wage changes in that sector (Column (2)). Instead, we estimate a significant and a large and positive pass-through coefficient in service-providing industries, and the instrument is significant at the 1% level. Thus, our IV results are consistent with a significant positive pass-through of wage changes to price changes in services, and essentially a zero pass-through in manufacturing.

4.2 Evolution of Pass-Through in Manufacturing

Is the low pass-through in manufacturing a recent phenomenon or has this always been the case? Documenting the time trend in manufacturing can be informative for understanding the heterogeneity between manufacturing and services, and eventually, the determinants of missing inflation.

Unfortunately, PPI data are only available from 2003 onward for most service-providing
Table 3: Pass-Through Regressions in Manufacturing

<table>
<thead>
<tr>
<th></th>
<th>(1) No TFP</th>
<th>(2) With TFP</th>
<th>(3) Time Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>∆Wage</strong></td>
<td>0.00153</td>
<td>0.0278</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0183)</td>
<td>(0.0180)</td>
<td></td>
</tr>
<tr>
<td><strong>∆TFP</strong></td>
<td>-0.198***</td>
<td>-0.151***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0138)</td>
<td>(0.0130)</td>
<td></td>
</tr>
<tr>
<td><strong>∆Pre-2010 Interaction</strong></td>
<td>0.0819***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0212)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>∆Post-2010 Interaction</strong></td>
<td>0.0409</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0332)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time Fixed Effects</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Industry Fixed Effects</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Adj. R-Sq.</strong></td>
<td>0.247</td>
<td>0.281</td>
<td>0.233</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>4,535</td>
<td>4,535</td>
<td>4,535</td>
</tr>
</tbody>
</table>

The "Time Interaction" column interacts a dummy variable that is equal to one if the time period is after 2009, and another dummy if the time period is up until that year.

TFP is total factor productivity.

industries. However, a longer time series going back to 1993 exists for manufacturing industries. We now focus on these industries and estimate pass-through coefficients for different time periods using the specification in (2).

Table 3 presents our findings. The first two columns show that even within the manufacturing industries for which we have extended data, the average pass-through is essentially zero, regardless of controlling for productivity. In this sense, the manufacturing industries we focus on are not dramatically different from those in our baseline sample. In the last column, we allow the pass-through coefficient to vary over time. Specifically, we estimate the effect for the periods before and after 2010 by interacting the wage change with a dummy for these periods. Our results indicate a sizable change in the price pass-through: For the period prior to 2010, increases in wages did translate into increases in prices—still by a lesser amount (8%) than the pass-through in the service sectors but above zero in a statistical sense. The pass-through declines substantially in the later period by about a half and becomes insignificant.

In order to analyze the evolution of pass-through in manufacturing more carefully and to determine the timing of the decline, we re-estimate our pass-through regression by interacting the wage change with six time period dummies comprising four year time intervals, capturing
1993-1996, 1997-2000, and so on until 2013-2016. Figure 6a depicts a gradual decline in these pass-through coefficients. According to our estimates, while the average pass-through in the manufacturing industry was close to 0.2 in the 1990s, in the latest period it has been close to zero.

4.3 The Role of Import Competition

One hypothesis for the low pass-through in manufacturing is that this sector is subject to competition with international producers. Therefore, firms may not be able to reflect increasing labor costs in prices because their downstream customers will be able to switch to foreign competitors. Moreover, if this hypothesis holds, the rise in international trade in the United States over the last several decades can explain the declining pass-through in manufacturing documented in the previous section, and consequently the missing inflation.

We now show that this hypothesis has merit by documenting a lower pass-through in industries with a higher exposure to trade. We proxy for trade competition in an industry with the import penetration in that industry as in Autor et al. (2013). Import penetration of industry $i$ is defined as

$$IP_{it} = \frac{\text{Imports}_{it}}{\text{Sales}_{it} - \text{Exports}_{it} + \text{Imports}_{it}},$$

where $\text{Imports}_{it}$ are imports by industry $i$ in year $t$, $\text{Exports}_{it}$ are the industry’s exports,
and Sales_{it} are the total sales in that industry. Since we only have a measure of import penetration for goods, we focus on the manufacturing sector for the period 1993–2016. We obtain imports and exports for each NAICS industry each year from the U.S. Census Bureau, available via Peter Schott’s website. Total sales for each industry are obtained from the ASM. A higher import penetration implies that a larger share of an industry’s U.S. sales is accounted for by imports from abroad, suggesting that U.S. firms in that sector are strongly exposed to foreign competition.

Figure 6b demonstrates that import penetration in the manufacturing sector has risen sharply since the early 1990s. We construct the figure by summing up imports, exports, and sales across all manufacturing industries and then computing import penetration for this aggregate. While in the early 1990s the U.S. manufacturing sector was relatively closed, exhibiting an import penetration of only about 14%, import penetration has since more than doubled to about 33%. Autor et al. (2013) and Pierce and Schott (2016) show that the sharp increase in imports from China over this period led to a significant decline in employment in the manufacturing sector.

We interact our measure of import competition in each industry with the wage change. We then estimate the modified pass-through regression

$$\Delta \ln(p_{it}) = \beta_0 \Delta \ln(w_{it}) + \beta_1 \Delta \ln(w_{it}) \ast IP_{it} + \alpha IP_{it} + \gamma X_{it} + \delta_i + \rho_t + \epsilon_{it},$$

(4)

where $IP_{it}$ is industry $i$’s import penetration in year $t$. The first column of Table 4 presents the results from this regression. We find that a higher import penetration significantly lowers pass-through in a given industry. While an industry with no imports exhibits a pass-through from wages to prices of about 0.08%, pass-through in an industry in which 50% of domestic sales originate from foreign firms is about zero. Since our regression incorporates time fixed effects and therefore picks up the aggregate increase in import penetration, this finding does not simply reflect our earlier result that pass-through in manufacturing fell over time, while at the same time import penetration rose. Instead, the results indicate that industries that experienced a relatively stronger increase in import penetration exhibit relatively lower pass-through.

As an alternative, we construct a dummy variable for whether in a given year an industry’s import penetration is above the 75th percentile of import penetration across all industries in that year. We also construct the complementary dummy for industries below the 75th percentile. Since the cut-off is recomputed in each year, the set of industries where a given dummy is equal to one changes from year to year. Column (2) of Table 4 shows that industries

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8https://sompks4.github.io/sub_data.html

9In a slight abuse of notation. We do not have quarterly import penetration data.
Table 4: Pass-Through Regressions and Import Penetration

<table>
<thead>
<tr>
<th></th>
<th>(1) With Import Penetration</th>
<th>(2) IP in Given Year</th>
<th>(3) IP Across Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔWage</td>
<td>0.0829**</td>
<td>-0.196***</td>
<td>-0.194***</td>
</tr>
<tr>
<td></td>
<td>(0.0330)</td>
<td>(0.0144)</td>
<td>(0.0144)</td>
</tr>
<tr>
<td>ΔWage × IP</td>
<td>-0.161**</td>
<td>0.0802***</td>
<td>0.107***</td>
</tr>
<tr>
<td></td>
<td>(0.0805)</td>
<td>(0.0255)</td>
<td>(0.0249)</td>
</tr>
<tr>
<td>ΔTFP</td>
<td>-0.195***</td>
<td>-0.195***</td>
<td>-0.195***</td>
</tr>
<tr>
<td></td>
<td>(0.0144)</td>
<td>(0.0144)</td>
<td>(0.0144)</td>
</tr>
<tr>
<td>ΔWage × Low IP</td>
<td>0.0802***</td>
<td>0.107***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0249)</td>
<td>(0.0246)</td>
<td></td>
</tr>
<tr>
<td>ΔWage × High IP</td>
<td>-0.0148</td>
<td>-0.0450*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0241)</td>
<td>(0.0246)</td>
<td></td>
</tr>
<tr>
<td>Time Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Adj. R-Sq.</td>
<td>0.280</td>
<td>0.283</td>
<td>0.286</td>
</tr>
<tr>
<td>N</td>
<td>4,202</td>
<td>4,202</td>
<td>4,202</td>
</tr>
</tbody>
</table>

IP refers to import penetration.  
"Low" is defined as industries below the 75th percentile of import penetration.  
"High" is defined as industries above the 75th percentile of import penetration.

with a high level of import penetration in a given year exhibit a pass-through from wages to prices that is statistically indistinguishable from zero. On the other hand, industries with low import penetration have pass-through of about 0.08.

In Column (3) of Table 4, we instead use the 75th percentile of import penetration across all years as cutoff. This regression analyzes whether pass-through is lower for an industry once it crosses a fixed threshold level of import penetration. Since import penetration rises over time, more industries are classified as having high import penetration in later years than in earlier years. The regression indicates again that low import penetration industries exhibit significantly positive pass-through from wages to prices while high import penetration industries do not.

Overall, our results provide evidence for the hypothesis that industries that are exposed to more competition from abroad cannot raise their prices in response to increasing wages, and therefore exhibit lower price inflation. As import penetration has risen significantly over the last decades, pass-through in manufacturing overall has declined.
5 Conclusions

In this paper, we have shown that a significant part of the missing inflation after the most recent recessions can be attributed to the lack of inflation in the goods-producing sector. We have traced this slowdown in goods inflation to a decline in the pass-through of wage shocks to prices in manufacturing using an instrumental-variables approach. We found strong evidence that rising import competition has led to this declining pass-through. As firms in the U.S. faced increasing foreign competition, they have found it harder to raise their prices in response to wage pressures.

Our paper complements the well-established literature on the role of anchoring of inflation expectations in explaining recent inflation dynamics such as Del Negro et al. (2015), Carvalho et al. (2017), Coibion and Gorodnichenko (2015), and Coibion et al. (2019). We document an additional channel operating via core goods inflation, which can account for the sluggishness of goods inflation relative to services inflation. This observation is also related to the flattening of the Phillips Curve that has been documented recently. An open question remains to which extend import competition and inflation expectations interact—an issue we leave to future work.
References


A Data appendix

A.1 Alternative Measures of Recovery

Figure A.1: Inflation versus GDP Growth from Four Previous Recessions

(a) 1982 Recession

(b) 1992 Recession

(c) 2003 Recession

(d) 2009 Recession
Figure A.2: Inflation from Four Previous Recessions

(a) 1982 Recession

(b) 1992 Recession

(c) 2003 Recession

(d) 2009 Recession
Figure A.3: Wage Growth versus GDP Growth from Four Previous Recessions

(a) 1982 Recession

(b) 1992 Recession

(c) 2003 Recession

(d) 2009 Recession
Figure A.4: Wage Growth from Four Previous Recessions

(a) 1982 Recession

(b) 1992 Recession

(c) 2003 Recession

(d) 2009 Recession
A.2 International Evidence

A.2.1 Canada

Figure A.5: Inflation versus Unemployment Recovery from Four Previous Recessions

(a) 1982 Recession
(b) 1992 Recession
(c) 2002 Recession
(d) 2009 Recession
A.2.2 United Kingdom

Figure A.6: Inflation versus Unemployment Recovery from Two Previous Recessions

(a) 1993 Recession

(b) 2011 Recession
A.2.3 Eurozone

Figure A.7: Inflation versus Unemployment Recovery from Two Previous Recessions

(a) 1993 Recession
(b) 2011 Recession