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Inflation Dynamics in Advanced Economies:

A Decomposition into Cyclical and Non-Cyclical Factors

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ABSTRACT: Inflation and unemployment rate were largely disconnected between 2000 and 2019 in advanced economies. We decompose core inflation into two parts based on the cyclical sensitivity of CPI components and document several salient facts: (i) both the cyclical and non-cyclical parts had surges across advaced economies in 2011, when unemployment rates had limited changes; (ii) the non-cyclical part had a downward trend between 2012 and 2019, which existed across countries, sectors, goods, and services; (iii) global indexes such as oil price, shipping costs, and a global supply chain pressure index do not explain the downward trend; and (iv) the cyclical part, after controlling for the impact of economic slack, also had a downward trend between 2012 and 2019. These patterns help disentangle competing explanations for the disconnect between inflation and unemployment rate. The approach has potential to help understand forces shaping price pressures during the pandemic and in the post-pandemic period ahead.

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WORKING PAPERS

Inflation Dynamics in Advanced Economies:

A Decomposition into Cyclical and Non-Cyclical Factors

Prepared by Weicheng Lian and Andreas Freitag[1]

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I. Introduction

Inflation and unemployment rate were largely disconnected in the 2000s in many advanced economies (AEs). The slope of the simple Phillips curve was close to zero between 2000 and 2019 in the United States (Stock and Watson (2019)), and Figure 1 shows a similar pattern for advanced economies as a group. There was almost no improvement in either headline inflation or core inflation for an average AE between 2011 and 2019, despite a steady decline in unemployment rate of around 3 percentage points, a pattern that the literature refers to as *missing reflation*.

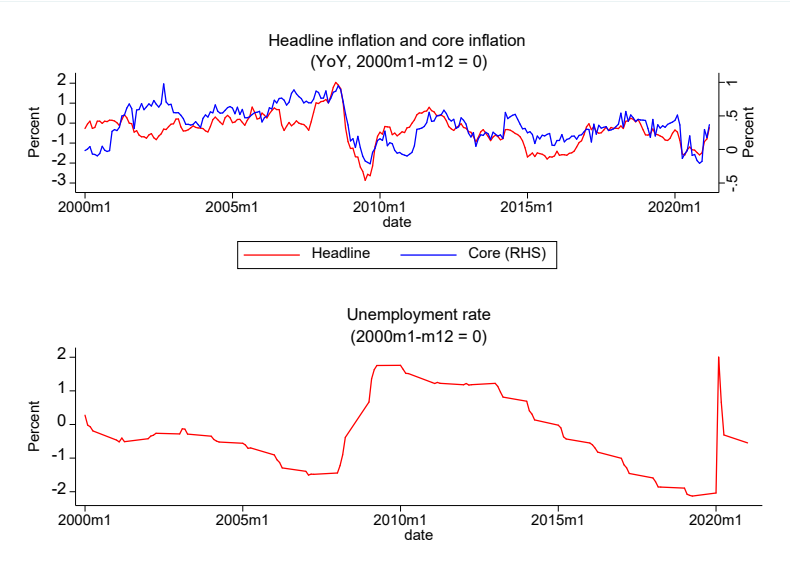
A consensus has not been achieved regarding why inflation and unemployment rate were disconnected, and few studies try to disentangle competing explanations, with an exception being Coibion and Gorodnichenko (2015). They focus on missing disinflation after the global financial crisis (GFC). The missing disinflation and the missing reflation may not share the same driver, and given competing views on these inflation puzzles, the driver behind dormant inflation processes still remains unclear.[1]

This paper develops an approach that tries to disentangle explanations for the disconnect puzzles, focusing on factors other than changes in economic slack. The idea goes as follows: if the intrinsic slope of the Phillips curve is significantly positive, as is consistently shown by studies in the literature (Coibion, Gorodnichenko, and Kamdar (2019)), it is possible that the upward pressure on inflation from steadily falling unemployment rates was offset by other forces that were also persistent. The key contribution of our paper is to reveal such forces and analyze their properties.

The important role played by factors that are not changes in economic slack in the disconnect puzzles is also implied by a finding of Stock and Watson (2019). They show that the relationship between a cyclically sensitive inflation measure and an activity gap measure has been stable in the past half a century in the United States, a sharp contrast with the dramatic flattening of a

[1] Hazell et al. (2020) argue that there is no missing disinflation or missing reflation as the inflation dynamics in the United States are broadly consistent with the prediction of their model, which features a small slope of the Phillips curve and a stable long-run expectation.

Figure 1. Headline Inflation, Core Inflation, and Unemployment Rate in Advanced Economies



Sources: CEIC, Eurostat, Haver Analytics, OECD stat, and authors' calculations.

Notes: The figure reports the time-fixed effects of a regression in which headline inflation, core inflation, and unemployment rate on regressed on time and country fixed effects for 28 AEs, with PPPGDP as the weight. See Appendix A for the country sample.

simple Phillips curve, suggesting that factors not captured by their inflation measure played an important role in weakening the association between unemployment rate and inflation.

To reveal the inflationary impact of factors that are not changes in economic slack, we focus on CPI components that are less sensitive to cyclical conditions than other CPI components, building upon a recent literature that highlights a difference of cyclical sensitivity across CPI components (Mahedy and Shapiro (2017) and Stock and Watson (2019) among others). Although these components are only a fraction of overall inflation, as long as the cause of the disconnect between inflation and unemployment rate across countries was not sector-specific, the inflation dynamics of these non-cyclical components (hereafter, non-cyclical components refer to those whose inflation is not sensitive to changes in economic slack) can still capture it.

We decompose core inflation into cyclical and non-cyclical parts (referred to as core cyclical inflation and core non-cyclical inflation hereafter), based on the cyclical sensitivity of a CPI component. We measure the cyclical sensitivity of a component using the median of the distribution of the correlation between the inflation of the component and unemployment gap

across AEs in the post-2000 period. We put first-digit components of the Classification of Individual Consumption by Purpose (COICOP) into two categories based on their cyclical sensitivity and use the weighted averages of the components' inflation to define core cyclical and core non-cyclical inflation, with the weights being proportional to the CPI weights.[2] We document a number of salient facts.

First, core cyclical inflation and core non-cyclical inflation had surges across advanced economies in 2011, when unemployment rates had limited changes. They on average increased by around 0.87 and 0.88 percentage points between December 2010 and December 2011, with narrow confidence bands, while the average unemployment rate declined by around 0.21 percentage points.[3] There is an interesting overlap between this episode of inflation surges and the missing disinflation period analyzed by Coibion and Gorodnichenko (2015). They examine inflation forecast error based on the short-term expectation of professional forecasters between 2009 and 2011, and interestingly, 2010Q4 – 2011Q2 had the largest positive surprises.

Second, core non-cyclical inflation had a downward trend between 2012 and 2019, which existed across countries, sectors, goods, and services. Core non-cyclical inflation on average declined by 1.1 percentage points between 2012 and 2019 while core cyclical inflation increased by 0.26 percentage points.

We note several interesting patterns regarding this downward trend: (i) The trend was not reversed between 2016 and 2019, when oil price started to rise. This feature suggests that oil price fluctuation may not be the primitive driver of the downward trend. (ii) The downward trend is robust to excluding from the exercise any of first-digit COICOP components, having the exercise restricted to CPI components classified as goods, or restricted to those classified as services. (iii) The downward trend was not driven by large countries. To show this, for core non-cyclical inflation, we estimate a Phillips curve equation augmented with two separate linear time trends for 2000-11 and 2012-19. Our estimation has equal weights across countries so that large

[2] The results are robust to using HP-filtered output gap rather than unemployment gap. Cyclical components of core inflation include "restaurants and hotels", "furnishings, household equipment, and routine maintenance of the house", "housing excluding gas and electricity", "food", and "recreation". Non-cyclical components of core inflation include "clothing and footwear", "communications", "education", "health", "miscellaneous goods and services". We exclude "transportation excluding energy" as an outlier, since it is relatively volatile and has a large weight in the CPI basket.

[3] Throughout the paper, without explanation, the averages are calculated using PPPGDP as the weight.

countries do not affect the estimation disproportionately. We find that the coefficient of the linear trend between 2012 and 2019, capturing a potential downward trend during this period, is significantly negative.

Third, global indexes such as oil price, shipping costs, and a global supply chain pressure index do not explain the downward trend of core non-cyclical inflation. We use these global indexes to capture global cost-push shocks and include them in the Phillips curve equation mentioned above. We find that they have insignificant or even negative impact on the core non-cyclical inflation, and whether to include these measures in the equation has little impact on the negative linear trend between 2012 and 2019. We measure shipping costs using the Baltic Dry Index (BDI) and use the global supply chain pressure index (GSCPI) constructed by Benigno, di Giovanni, Groen, and Noble (2022). Although the GSCPI incorporates the information in the BDI, we find that the results are not sensitive to how we include global indexes. These patterns, arguably, suggest that cost-push shocks were not the cause of the downward trend.

The last pattern we want to highlight is that core cyclical inflation, after controlling for the impact of economic slack, also had a downward trend between 2012 and 2019. Recognizing the endogeneity issues of identifying the impact of economic slack on inflation (Mavroeidis, Plagborg-Møller, and Stock (2014)), we construct this pattern based on a weak assumption that the OLS estimation of a Phillips curve equation for core cyclical inflation yields a lower bound of its true slope of the Phillips curve.[4] With this lower bound, given unemployment rates were falling between 2012 and 2019, we can obtain an upper bound for the linear time trend of non-cyclical factors behind core cyclical inflation during this period, to identify the negative trend.

How to interpret these findings? They imply that counter-cyclical movements of inflation driving forces that did not come from cost-push shocks, core goods price inflation, country- or sector-specific factors, caused the disconnect between inflation and unemployment rates. We highlight these three sets of factors, as they have been proposed by previous studies as the reason either for the disconnect between inflation and unemployment rate or missing reflation specifically

[4] This assumption is plausible given the arguments in the literature that supply shocks and measurement errors can create downward bias for the OLS estimation (McLeay and Tenreyro (2019)) and the fact that the simple Phillips curve for the overall inflation is horizontal between 2000 and 2019 but the intrinsic slope is significantly positive when endogeneity issues are resolved (Hazell et al. (2020)).

(McLeay and Tenreyro (2019), Heise, Karahan and Şahin (2022), and Mahedy and Shapiro (2017)). While it is challenging to further narrow down the explanations, among the remaining candidates to explain dormant inflation processes, counter-cyclical movements of inflation expectation of firms seem to be more plausible rather than measurement errors, given broad-based movements across countries and sectors of this trend. This is consistent with the findings of the recent literature on inflation expectations of firms that they are not fully anchored (Coibion and Gorodnichenko (2015), Kumar, Afrouzi, Coibion, and Gorodnichenko (2015), Jorgenson and Lansing (2019), and Candia, Coibion, and Gorodnichenko (2021)).[5]

The rest of the paper is organized as follows. Section II discusses how our paper connects to the recent inflation literature. Section III explains the construction of inflation measures. Section IV presents the four sets of facts. Section V concludes.

II. Relation to the Literature

Our paper contributes to the literature that constructs inflation measures to better understand inflation trends (Dolmas (2005), Ball and Mazumder (2011, 2019), Dolmas and Jim (2019), Stock and Watson (2019), and Ball, Leigh, Mishra, and Spilimbergo (2021), among others). Existing inflation measures such as the median CPI and the trimmed mean PCE tend to have considerable weights on cyclically sensitive components (Stock and Watson (2019)). The cyclically sensitive inflation (CSI) constructed by Stock and Watson (2019) presumably maximizes the weights on cyclically sensitive components. By contrast, we construct an inflation measure with large weights on components that are not cyclically sensitive, which is critical for revealing the role of factors that are not changes in economic slack in driving inflation dynamics.

Our paper contributes to an emerging literature on the disconnect between inflation and unemployment rate. Stock and Watson (2019) has a detailed summary of this strand of literature. Existing studies can be broadly put into seven categories. The first is not-fully-anchored expectation of firms. Coibion and Gorodnichenko (2015) argue counter-cyclical movements of

[5] Lian and Sun (forthcoming) reaches a similar conclusion using a different approach, by developing an inflation framework based on those of Hazell et al. (2020) and Jorgenson and Lansing (2019) and quantifying the role of not-fully-anchored long-run expectations in inflation dynamics in AEs.

expectations explained the missing disinflation.[6] The second involves cost-push shocks. McLeay and Tenreyro (2019) argue that with central banks being more effective in counteracting demand shocks, the Phillips curve can be flatter due to cost-push shocks. The third highlights pricing behaviors of liquidity-constrained firms during a financial crisis, which can lead inflation to be more resilient in responding to weaker demand (Gilchrist et al. (2017)). The fourth explores non-cyclical factors. Stock and Watson (2019) finds that the CSI, constructed by excluding non-cyclical factors (they highlight prices being determined in international markets and measurement errors), has a stable relationship over time with an activity gap measure. The fifth highlights international factors (Forbs et al. (2019), Obstfeld (2019), and Heise, Karahan and Şahin (2022)), whose rise, intuitively, can weaken the role of domestic conditions in the pricing of firms.[7] The sixth studies sector-specific factors. Mahedy and Shapiro (2017) highlights the role of health sector prices in the weak inflation after the Great Recession in the United States. The seventh argues that the missing disinflation and the missing reflation reflect a stable long-run inflation expectation and a small slope of the Phillips curve (Hazell et al. (2020)). Their model explains the limited decline in inflation in 2009 well. Studies have explored why the slope of the Phillips curve is small, whether it has declined significantly over time, and whether structural factors played a role (Forbes (2018), Del Negro et al. (2020), Hazell et al. (2020), Heise, Karahan and Şahin (2022)).[8]

The difference between our paper and previous studies has three aspects. First, we decompose core inflation dynamics in a cross-country context, and many studies focus on the inflation dynamics in the United States. Second, we explore both the missing disinflation and the missing reflation, whereas most studies focus on one of the two. Third, we study the role of competing factors that are not changes in economic slack, whereas many studies focus on the slope of the Phillips curve.

[6] Jorgenson and Lansing (2019) shows that negative inflation surprise can interact with not-fully-anchored inflation expectations to result in a horizontal Phillips curve after the GFC.

[7] Rogoff (2003) and Ball (2006) are earlier studies on the impact of globalization on inflation.

[8] There are also studies exploring whether latent slack played a role in the flat Phillips curve (Hong et al. (2018) among others). Several studies highlight the fact that the wage Phillips curve has not flattened much compared with the price Phillips curve (Obstfeld (2019), Rognlie (2019), Del Negro et al. (2020), and Heise, Karahan and Şahin (2022)).

Our paper is connected with recent studies that highlighted the disruption to global supply chains as a key factor in driving inflation dynamics during the pandemic (Benigno, di Giovanni, Groen, and Noble (2022), Celasun et al. (2022), and Del Negro et al. (2022)). Interestingly, our patterns suggest that global cost-push shocks did not cause persistent movements in core non-cyclical inflation before the pandemic.

III. Core Cyclical Inflation and Core Non-Cyclical Inflation

3.1 Difference in cyclical sensitivity across CPI components

Our exercises involve all advanced economies for which we have a COICOP breakdown of the CPI basket that is available for more than five years before the COVID-19 pandemic. They include 28 countries.[9] The key data sources are Eurostat, Haver Analytics, and the OECD stat.

Following Stock and Watson (2019), we define the cyclical sensitivity of a CPI component based on the correlation between its inflation and economic slack. Using the unemployment gap (the difference between unemployment rate and the natural rate of unemployment) as the measure of economic slack and calculating the correlation for the period between January 2000 and December 2019, we define the cyclical sensitivity of a CPI component as the median of the distribution of its correlation cross advanced economies.[10][11]

Figure 2 presents the cyclical sensitivity for 12 one-digit COICOP components. We also show the inter-quartile range of the cross-AE distribution of the correlation and highlight components that are part of the core inflation.

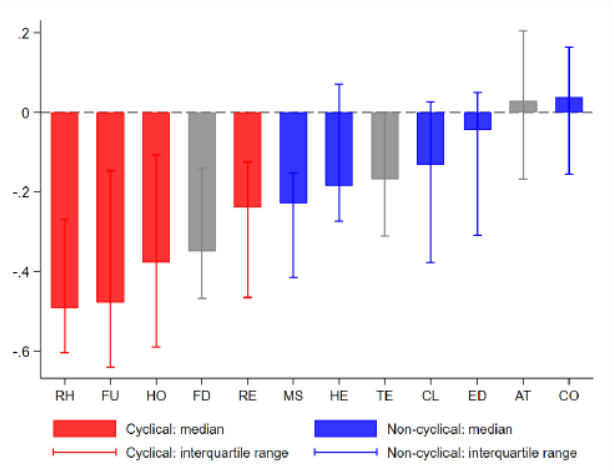
There are two patterns. First, the cyclical sensitivity varies significantly across CPI components. The most cyclical component is “restaurants and hotels”, with the median of the distribution around -0.5, and the most non-cyclical component is “communications”, with the median being slightly positive.

[9] The 28 AEs are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[10] This is subject to data availability, as some countries have their detailed breakdown available after 2000. We use the natural rate of unemployment estimated by the OECD, and find that the results are robust for replacing the unemployment gap with the HP-filtered output gap.

[11] The results are robust to using HP-filtered output gap as the measure of economic slack.

Figure 2. Correlation between Components' Inflation and Unemployment Gap in Advanced Economies: 2000-19 1/



Sources: Eurostat, Haver Analytics, OECD stat, and authors' calculations.

Notes: The figure reports, for 12 COICOP components, the median and interquartile ranges of the cross-AE distribution of the correlation between inflation at the component level and unemployment gap. Energy sub-components are removed. The unemployment gap is defined as the difference between unemployment rate and the non-accelerating inflationary rate of unemployment (NAIRU), which is reported by the OECD stat. The abbreviations in the horizontal axis are defined as follows. AT: alcohol and tobacco; CL: clothing and footwear; CO: communications; ED: education; FD: food; FU: furnishings, household equipment, and routine maintenance of the house; HE: health; HO: housing excluding gas and electric utility; MS: miscellaneous goods and services; RE: recreation; RH: restaurants and hotels; TE: transportation excluding energy.

Second, for the most cyclical components, the correlation between their inflation and unemployment gap is negative for the majority of AEs. For components such as "restaurants and hotels", "furnishings, household equipment, and routine maintenance of the house", "housing excluding gas and electric utility", "food", "recreation", more than 75% of countries have negative correlation between their inflation and unemployment gap.

Based on the cyclical sensitivity, we define cyclical CPI components as "restaurants and hotels", "furnishings, household equipment, and routine maintenance of the house", "housing excluding gas and electricity", "food", and "recreation", and the rest as non-cyclical components.

Interestingly, cyclical components defined in our paper tend to be PCE components that receive positive weights in the cyclically sensitive inflation (CSI) constructed by Stock and Watson (2019). Table A.2 reports the weights of the CPI components in the CSI, which come from a maximization problem in which the weights are chosen to maximize the correlation between the

weighted average of inflation and economic slack for the United States. Although the mapping between COICOP first-digit components to PCE broad categories is not one-for-one, cyclical components with unambiguous mapping tend to have positive weights in the CSI. They include "restaurant and hotels" (which corresponds to "food services and accommodations"), "food" (which corresponds to "food and beverages purchased for off-premises consumption"), and "recreation" (which corresponds to "recreation services" and "recreation goods and vehicles"). Similarly, non-cyclical components with unambiguous mapping tend to have zero weights in the CSI. The examples include "health" (which corresponds to "health care"), "transportation excluding energy" (which corresponds to "transportation services" and "motor vehicles and parts"), and "clothing and footwear" (which corresponds to "clothing and footwear"). One exception is "furnishing", which is classified as cyclical in our paper but has zero weight in the CSI, it has a large correlation with the cyclical slack, as is shown in the last column of Table A.2.

What causes the correlation between inflation and economic slack to vary across components? Tradability of goods and services, measurement issues, and regulation can all play a role. As is summarized by Stock and Watson (2019) (p.19), "the sectors with the highest cyclical correlations tend to be dominated by services that have prices determined in local (non-tradable) markets and which are relatively well-measured: housing services, recreational services, and food services and accommodations." By contrast, "the sectors with the smallest cyclical correlations tend to be internationally traded goods (e.g. gasoline); sectors with prices that are heavily influenced by internationally traded goods (e.g. transportation services, which relies on refined petroleum products); sectors with managed, negotiated, or regulated prices (health care and some transportation services); and/or sectors with prices that are poorly measured (financial services and insurance and clothing & footwear)."

3.2. Core cyclical inflation and core non-cyclical inflation

We split core inflation into two parts based on the cyclical sensitivity of CPI components. We exclude transportation as an outlier, since its price inflation is relatively volatile and has a large weight in the CPI basket. Core cyclical inflation is constructed as the weighted average of the following components: "furnishings, household equipment and routine maintenance of the house"; "restaurants and hotels"; "housing excluding gas and electric utility"; and "recreation

and culture". Core non-cyclical inflation is constructed based on the following components: "miscellaneous goods and services", "health", "clothing", "education", and "communications".

We use three-month trailing averages to reduce high-frequency noises:

$$\pi_{i,t}^{C}=\frac{1}{3}\left(\sum_{i=1}^{N^C}\omega_{i,t}^{C}\frac{P_{i,t}^{C}}{P_{i,t-12}^{C}}+\sum_{i=1}^{N^C}\omega_{i,t-1}^{C}\frac{P_{i,t-1}^{C}}{P_{i,t-13}^{C}}+\sum_{i=1}^{N^C}\omega_{i,t-2}^{C}\frac{P_{i,t-2}^{C}}{P_{i,t-14}^{C}}\right),$$

$$\pi_{i,t}^{NC}=\frac{1}{3}\left(\sum_{i=1}^{N^{NC}}\omega_{i,t}^{NC}\frac{P_{i,t}^{NC}}{P_{i,t-12}^{NC}}+\sum_{i=1}^{N^{NC}}\omega_{i,t-1}^{NC}\frac{P_{i,t-1}^{NC}}{P_{i,t-13}^{NC}}+\sum_{i=1}^{N^{NC}}\omega_{i,t-2}^{NC}\frac{P_{i,t-2}^{NC}}{P_{i,t-14}^{NC}}\right),$$

where C and NC indicate cyclical and non-cyclical core inflation.

3.3 Common trends of core cyclical inflation and core non-cyclical inflation

We estimate the common trends of core cyclical inflation and core non-cyclical inflation using the following regression function:

$$Z_{i,t}=\mu_t^Z+\delta_i^Z+\varepsilon_{i,t}^Z, \quad (1)$$

Where $Z_{i,t}$ indicates core cyclical inflation and core non-cyclical inflation, and μ_t^Z and δ_i^Z are time and country fixed effects. We estimation equation (1) using the GDP based on Purchasing Power Parity (PPPGDP) as the weight, to avoid the results being driven by small countries.

IV. Empirical Facts

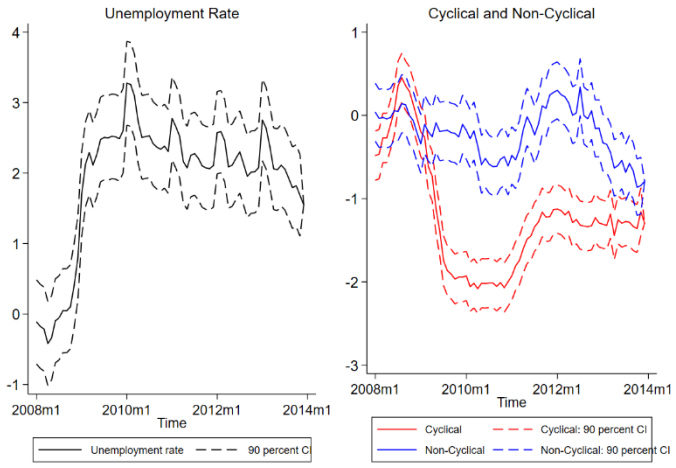
This section documents several sets of empirical patterns to explore the cause of dormant inflation processes between the global financial crisis and the COVID-19 pandemic.

4.1 Fact 1: Inflation surges in 2011

In this section, we show that core cyclical inflation and core non-cyclical inflation had surges across advanced economies in 2011, when unemployment rates had limited changes. Figure 3 shows that core cyclical inflation and core non-cyclical inflation increased by 0.87 and 0.88 percentage points between December 2010 and December 2011, when the unemployment rate declined by only 0.2 percentage points.

These inflation surges should not be driven by changes in economic slack. For the increase to be explained by contemporaneous changes in unemployment rate, we need the slope of the Phillips

Figure 3. Surges in Core Cyclical and Non-Cyclical Inflation in 2011



Notes: The figure reports the point estimation and 90 percent confidence bands of the time fixed effects of equation (1), with the dependent variable being unemployment rate, core cyclical inflation, and core non-cyclical inflation and PPPGDP as the weight. See the text for the definition of core cyclical inflation and core non-cyclical inflation.

curve to be around 4. The literature estimate for the slope of the Phillips curve is much smaller than this value (Coibion, Gorodnichenko, and Kamdar (2019)).

The co-movement between core cyclical inflation and core non-cyclical inflation in 2011 was much stronger than what happened in 2009. Between September 2008 and December 2009, when the average unemployment rate increased by 2.56 percentage points, core cyclical inflation declined by 2.3 percentage points and core non-cyclical inflation only 0.23 percentage points.

The inflation surges help shed light on a debate regarding whether missing disinflation existed after the global financial crisis. On the one hand, Coibion and Gorodnichenko (2015) found positive inflation surprises relative to professional forecasters' short-term projection between 2009 and 2011, which were mostly above the historical relationship between this inflation surprise and unemployment rate. They argue the pattern was driven by rising oil prices and not-fully-anchored inflation expectations of firms. On the other hand, Hazell et al. (2020) show that the decline in inflation in 2009 was consistent with a stable long-run inflation expectation and a limited impact of rising unemployment rate, due to a small slope of the Phillips curve (which they estimate using a regression across states of the United States).

While there is a difference between the two studies in the proxy used to capture the expectation of firms, the inflation surge in 2011 in the United States is not entirely explained by the model of Hazell et al. (2020). Moreover, it is interesting to note that the quarters with the largest positive deviation from the historical relationship between inflation surprise and unemployment rate found by Coibion and Gorodnichenko (2015) were 2009Q2 – 2009Q4 and 2010Q4 – 2011Q2. The coincidence between inflation surges across advanced economies and positive inflation surprises in 2011 suggests that some factors that are not changes in economic slack played a significant role in driving up inflation in both the United States and other advanced economies.

This finding contributes to the debate on missing disinflation as it suggests that one should not only explore a potential difference between long-term and short-term expectation of professional forecasters in capturing the inflation expectation of firms, but also the counter-cyclical factors that caused inflation surges in 2011.[12]

Finally, there was a reversal of the inflation surge in 2011 between 2012 – 2013, although at a more gradual pace compared with the surge.

4.2 Fact 2: The downward trend of core non-cyclical inflation

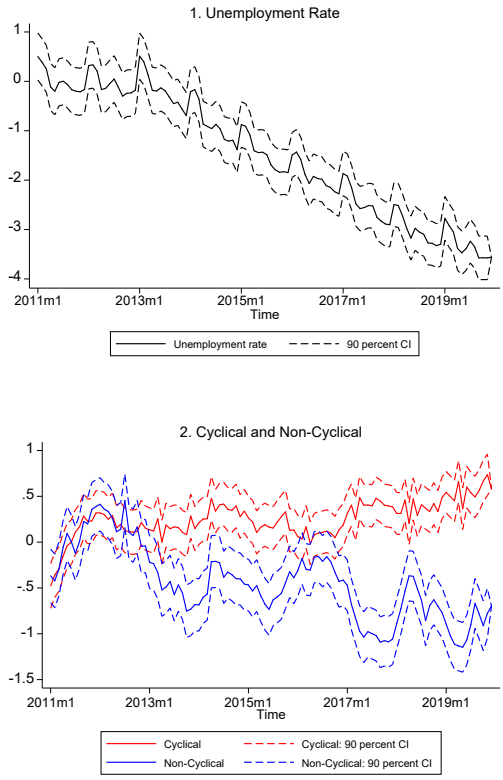
In this section, we show that the non-cyclical part of the core inflation (core non-cyclical inflation) had a downward trend between 2012 and 2019, which was broad-based across countries, sectors, goods, and services. Figure 4 shows that core non-cyclical inflation declined between 2011 and 2019. It declined by 1.1 percentage points between January 2012 and December 2019, and the decline was statistically significant. It is important to note that the decline was not reversed between 2016 and 2019, when the oil price increased.

Reflecting a removal of this downward trend from core inflation, the cyclical part of core inflation (core cyclical inflation) recovered to a level in 2019 that was higher than that in 2011, although the difference between the two is not statistically significant.

Previous studies propose cost-push shocks, core goods price inflation, and country- and sector-specific factors as the cause of a disconnect between inflation and unemployment rate or missing

[12] Note that even after they consider contemporaneous effects from oil price changes, 2009 Q3 – 2009 Q4 and 2010Q4 – 2011Q2 continued to be those with the largest deviation from the historical relationship.

Figure 4. Unemployment Rate, Core Cyclical Inflation, and Core Non-Cyclical Inflation: 2011-19



Notes: The figure reports the point estimation and 90 percent confidence bands of the time fixed effects of equation (1), with the dependent variable being unemployment rate, core cyclical inflation, and core non-cyclical inflation and PPPGDP as the weight. See the text for the definition of core cyclical inflation and core non-cyclical inflation.

reflation specifically (Mcleay and Tenreyro (2019), Heise, Karahan and Şahin (2022), and Mahedy and Shapiro (2017)). In the rest of this section and in the next section, we explore whether these factors caused the downward trend of core non-cyclical inflation.

4.2.1 Downward trends of core non-cyclical inflation across goods and services

To explore whether the downward trend was driven by core goods prices, we check whether it existed also within components classified as services.[13] We use the name of CPI components to determine whether they are goods and services. Table A.3 lists our classification. In this exercise,

[13] Celasun, Lian, and Hong (2018) present patterns to suggest that the missing reflation puzzle does not exist only for goods but also for services.

we drop components for which we cannot clearly identify as either goods or services (GS in the table). Figure 5 reports the estimated common time trends for cyclical goods, non-cyclical goods, cyclical services, and non-cyclical services, where the inflation of cyclical goods are weighted averages of core CPI components classified as goods and whose first-digit COICOP component is classified as cyclical, and similarly for non-cyclical goods, cyclical services, and non-cyclical services.

Figure 5 shows that the inflation surges in 2011 were broad-based across both goods and services. All four components had a significant increase in 2011, with similar timing and magnitude. Cyclical goods and non-cyclical goods increased by 1.08 and 1.56 percentage points between December 2010 and December 2011, while cyclical services and non-cyclical services increased by around 0.79 and 0.86 percentage points.

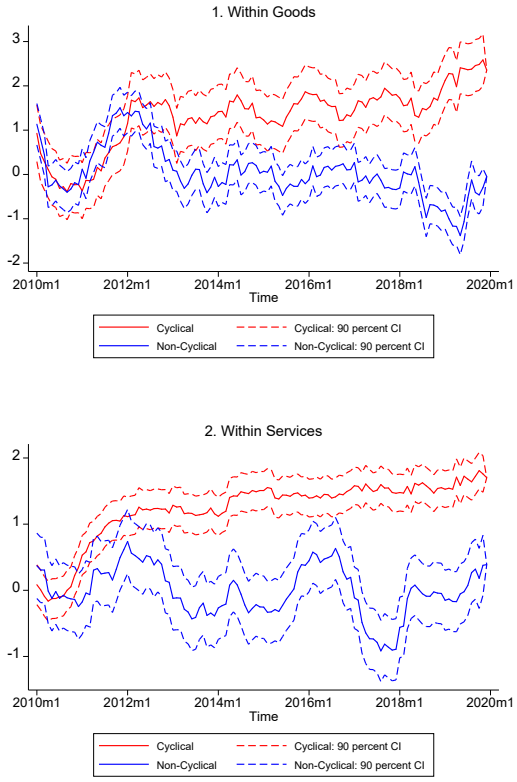
Both the divergence between cyclical and non-cyclical components and the downward trend of the non-cyclical part hold within goods and within services between 2012 and 2019. Both cyclical goods and cyclical services further recovered between January 2012 and December 2019. They increased by 1.20 and 0.59 percentage points. By contrast, both non-cyclical goods and non-cyclical services declined between January 2012 and December 2019. They declined by 1.45 and 0.35 percentage points.

4.2.2 Downward trends of core non-cyclical inflation across sectors

To explore whether the downward trend is driven by sector-specific factors, we check whether it is sensitive to the exclusion of first-digit COICOP components from the construction of non-cyclical core inflation. We focus on the health sector, in light of Mahedy and Shapiro (2017)'s argument that the price in this sector contributed to weak inflation in the United States after the Great Recession. We delegate the results in which we exclude other COICOP components to Appendix B.

Figure 6 suggests that the downward trend of core non-cyclical inflation and its divergence from core cyclical inflation between 2011 and 2019 were not caused by the health care component. After excluding it, the average increase in non-cyclical core inflation from December 2010 to December 2011 was 1.21 percentage points, and its decline from January 2012 to December

Figure 5. Unemployment Rate, Core Cyclical Inflation, and Core Non-Cyclical Inflation: 2011-19, within Goods and within Services



Sources: Eurostat, Haver Analytics, OECD stat, and authors' estimations.

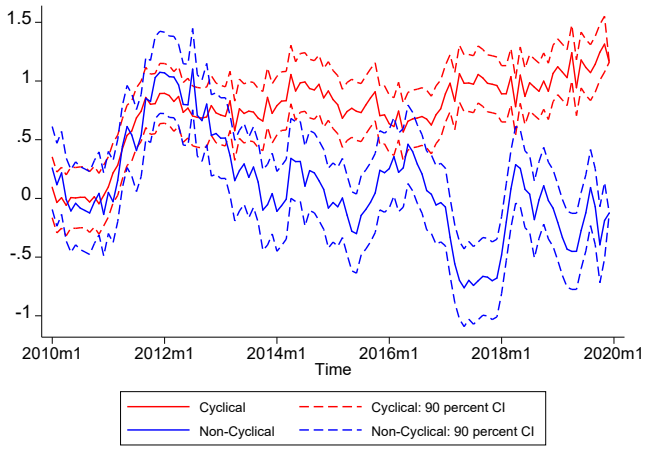
Notes: The figure reports the point estimation and 90 percent confidence bands of the time fixed effects of equation (1), with the dependent variable being unemployment rate, core cyclical goods inflation, core non-cyclical goods inflation, core cyclical services inflation, core non-cyclical services inflation, and PPPGDP as the weight. See the text for the definition of core cyclical inflation and core non-cyclical inflation, and Table A.3 for the definition of goods and services subcomponents.

2019 was 1.19 percentage points. Figure B1 suggests that both the downward trend and the divergence pattern are robust to excluding any of other first-digit COICOP components.

4.2.3 The downward trend of core non-cyclical inflation being broad-based across countries

To explore whether the downward trend of core non-cyclical inflation is driven by country-specific factors, we check whether it exists for an average AE in our sample. The earlier patterns already suggest that it is not driven by small countries, given we use PPPGDP as the weight to construct common time trends. To further explore whether it is driven by large countries, we

Figure 6. Unemployment Rate, Core Cyclical Inflation, and Core Non-Cyclical Inflation: 2011-19, Excluding Health Care



Sources: Eurostat, Haver Analytics, OECD stat, and authors' estimations.

Notes: The figure reports the point estimation and 90 percent confidence bands of the time fixed effects of equation (1), with the dependent variable being unemployment rate, core cyclical goods inflation, core non-cyclical goods inflation, core cyclical services inflation, core non-cyclical services inflation, and PPPGDP as the weight. See the text for the definition of core cyclical inflation and core non-cyclical inflation. The health care is excluded from the core non-cyclical inflation.

estimate a linear time trend between 2012-19 for core non-cyclical inflation in a Phillips curve equation, using equal weights across countries.

We estimate the following equation for the period between December 2012 and December 2019. We focus on the coefficient of the linear time trend:

$$\pi_{i,t}^{NC} = \alpha_i + \beta u_{i,t} + \varphi t + \varepsilon_{i,t}^{Z}, \quad (2)$$

with the standard errors clustered at the country level.

Admittedly, an OLS estimation of equation (2) may lead to a biased estimate of β. Given that the unemployment gap was falling between 2012 and 2019, a downward bias may actually dampen the estimated downward trend. Given various critiques about an OLS estimation of the Phillips curve (McLeay and Tenreyro (2019)), it is plausible for the bias to be downward in estimating equation (2).

Table 1 confirms that there is a negative linear trend between 2012 and 2019 as we estimate equation (2) with equal weights across countries. This finding holds if we estimate equation (2)

Table 1. Drivers of Core Non-Cyclical inflation: Role of Global Factors

VARIABLES	(1) 2012Q1 - 2019Q4	(2) 2012Q1 - 2019Q4	(3) 2012Q1 - 2019Q4	(4) 2012Q1 - 2019Q4	(5) 2000Q1 - 2019Q4	(6) 2000Q1 - 2019Q4	(7) 2000Q1 - 2019Q4	(8) 2000Q1 - 2019Q4
Unemployment gap	-0.121	-0.120	-0.121	-0.121	-0.0925	-0.101	-0.109	-0.111
	(0.0762)	(0.0749)	(0.0756)	(0.0757)	(0.0751)	(0.0725)	(0.0730)	(0.0726)
Linear time trend	-0.0282**	-0.0253**	-0.0318***	-0.0330***	-0.00632	-0.0142	0.00217	0.00303
	(0.0116)	(0.0115)	(0.00888)	(0.00900)	(0.0108)	(0.0120)	(0.0126)	(0.0125)
Linear time trend ×					-0.0189	-0.00822	-0.0368*	-0.0400*
1{t >= 2012Q1 & t <= 2019Q4)					(0.0188)	(0.0196)	(0.0216)	(0.0210)
Global supply chain		-0.0623	-0.124	-0.139		0.00337	-0.0475	-0.0561
pressure index		(0.111)	(0.0884)	(0.0908)		(0.0509)	(0.0495)	(0.0520)
Δ log (Oil price)		-0.113				-0.346*		
		(0.217)				(0.190)		
Log (Oil price)			-0.258	-0.282			-0.464**	-0.479**
			(0.248)	(0.244)			(0.188)	(0.191)
Δ log (Food price)		1.073	1.129	1.054		0.573	0.526	0.598
		(0.850)	(0.685)	(0.686)		(0.707)	(0.793)	(0.775)
Δ log (BDI)		-0.158	-0.140			-0.112	-0.132**	
		(0.101)	(0.0921)			(0.0714)	(0.0640)	
Δ BDI				-8.25e-05				-3.39e-05
				(7.18e-05)				(2.03e-05)
1{t >= 2012Q1 & t <= 2019Q4)					3.708	1.566	7.527	8.227*
					(3.917)	(4.029)	(4.545)	(4.430)
Country-fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Observations	720	720	720	720	1,686	1,625	1,625	1,625
R-squared	0.332	0.339	0.341	0.340	0.258	0.273	0.274	0.274
Linear time trend								
+ Linear time trend ×					-0.0224**	-0.0209*	-0.0347**	-0.0370***
1{t >= 2012Q1 & t <= 2019Q4)					(0.0101)	(0.0111)	(0.0116)	(0.0109)

Standard errors are reported in the parantheses and clustered at the country level
*** p<0.01, ** p<0.05, * p<0.1

only for the period between 2012 and 2019 or if we estimate it for the entire period, allowing separate linear time trends before and after 2012. In column (1) and (the last row of) column (5), we see that the coefficient of the linear trend is negative and statistically significant. Based on the estimated coefficient in column (1), they imply a cumulative decline in core non-cyclical inflation of 0.924 percentage points, broadly consistent with what we get from common time trends of core non-cyclical inflation. These patterns support the claim that the downward trend is not driven by country-specific factors.

4.3 The downward trend not driven by cost-push factors measured by global indexes

In this section, we explore whether cost-push shocks caused the downward trend of core non-cyclical inflation. We study whether global indexes such as oil prices, shipping costs, and a global supply chain pressure index explain the downward trend of core non-cyclical inflation.

We augment equation (2) with global indexes:

$$\pi_{i,t}^{NC} = \alpha_i + \beta u_{i,t} + \vec{\gamma} \cdot \vec{Z}_t + \varphi t + \varepsilon_{i,t}^{Z}, \quad (3)$$

where $\vec{Z}_t$ include oil price, food price, shipping costs, and a global supply chain disruption index. We proxy global shipping costs using the Baltic Dry Index and use the Global Supply Chain Pressure index constructed by Benigno, di Giovanni, Groen, and Noble (2022).

We explore two patterns: (i) whether the coefficient of the linear trend φ in equation (2) is sensitive to the inclusion of global factors, in terms of both its sign and magnitude, (ii) whether global factors have significant impact on core non-cyclical inflation.

Table 1 reports the results of estimating equation (3) with different combinations of global factors. Coibion and Gorodnichenko (2015) finds that the level of oil price rather the change in oil price captures the impact of oil price on household expectation better. We try both for robustness. We also try the change of the level and the change of the log level of the BDI for robustness. Whenever variables are defined as changes, they refer to differences relative to 12 months ago to be consistent with the definition of core cyclical inflation and core non-cyclical inflation.

For the two patterns, we get salient results. First, the global supply chain pressure index and food prices do not have significant impact on core non-cyclical inflation. The coefficients of oil price and the BDI are insignificant in most cases and sometimes significantly negative. Second, the downward trend of non-cyclical core inflation is not significantly different after controlling for global indexes. For example, the time trend estimates in the columns (2) – (4) are similar to that in the column (1), and similarly when we compare results in the columns (6) – (8) with that in the column (5).

These findings make it questionable that cost-push shocks were the driver of the downward trend of core non-cyclical inflation across advanced economies. The findings suggest that for cost-

push shocks to be the driver, they should satisfy all four conditions: (i) they affect more than one sectors; (ii) they influence multiple countries; (iii) they are not captured by any of the global indexes mentioned above; (iv) firms responded to these cost-push factors significantly, while they absorbed the impact of oil prices, shipping costs and global supply chain disruption without passing the cost pressure to consumers. To the best of our knowledge, no studies have proposed a concrete cost-push shock to explain the disconnect puzzles that meets all these conditions.

4.4 Fact 4: Downward trend of core cyclical inflation

In this section, we show that core cyclical inflation, after we exclude from it the inflationary impact of changes in economic slack, had a downward trend between 2012 and 2019.

We assume that core cyclical inflation $\pi_{i,t}^{C}$ satisfies the following equation:

$$\pi_{i,t}^{C} = \alpha_i^{C} + (\beta^{C} + b^{C})u_{i,t} + \varepsilon_{i,t}^{C}, \tag{3}$$

where $u_{i,t}$ is the unemployment gap, $\varepsilon_{i,t}^{C}$ captures non-cyclical factors. $\beta^{C} + b^{C}$ is the true slope of the Phillips curve, and we write it as a sum of two terms to make it easier to present our idea that an OLS estimation can only get a biased estimate of the true slope, which we later denote as β^{C}.

Our goal is to determine the sign of the underlying trend of $\varepsilon_{i,t}^{C}$, i.e., factors other than changes in economic slack that affect core cyclical inflation.

We have the following assumptions:

(A1) $u_{i,t} = \alpha_i^{u} + \beta^{u}t + v_{i,t}^{u}$, and $\beta^{u} < 0$;
(A2) $\varepsilon_{i,t}^{C} = \alpha_i^{\varepsilon C} + \beta^{\varepsilon C}t + v_{i,t}^{\varepsilon C}$;
(A3) $cov\left(t, v_{i,t}^{u}\right) = cov(t, v_{i,t}^{\varepsilon C}) = 0$.

Assumption (A1) assumes that unemployment rate follows a downward trend, which holds for the period between 2012 and 2019. Assumptions (A2) and (A3) are technical assumptions that make the interpretation of the results easier.

Lemma 1 Under assumptions A1 – A3, an OLS regression of $\pi_{i,t}^{C} - \beta^{C}u_{i,t}$ on the linear time trend yields an upper bound of the trend of factors that are not changes in economic slack and that drive core cyclical inflation.

Proof: The estimation gives $\beta^{\varepsilon C} + \beta^{u} b^{C}$. Since $b^{C} < 0$, $\beta^{\varepsilon C} + \beta^{u} b^{C} > \beta^{\varepsilon C}$. *Q.E.D.*

To implement this strategy, we use the slope of the Phillips curve estimated for the period between 2000Q1 and 2019Q4 as a lower bound for the slope of the Phillips curve between 2012Q1 and 2019Q4. We have some flexibility in choosing the sample period to estimate the slope of the Phillips curve. In our experiments, we find that using a longer sample period (i.e. 2000Q1-2019Q4) is critical. The reason is that it helps get a steeper slope of the Phillips curve, which in turn generates a stronger the downward trend of $\varepsilon_{i,t}^{C}$.

A concern could be whether the slope of the Phillips curve has been stable during the post-2000 period. It is possible that the lower bound of the slope of the Phillips curve for the period between 2000Q1 and 2019Q4 may not be that for the period between 2012Q1 and 2019Q4. This concern is mitigated by the findings in the literature that the slope of the Phillips curve has been broadly stable between 2000Q1 and 2019Q4. For example, Blanchard, Cerruti, and Summers (2015)'s estimation suggests that the slope of the Phillips curve has little change after the 1990s.[14]

With these arguments, here are the results from implementing the strategy. First, we get β^{C} from an OLS estimation in which core cyclical inflation is regressed on unemployment gap for the period between 2000Q1 and 2019Q4 and obtain $\beta^{C} = -0.297$. Second, we estimate the following equation at the quarterly frequency for the period between 2012Q1 and 2019Q4:

$$\pi_{i,t}^{C} + 0.297 u_{i,t}^{C} = \alpha_i + \hat{\beta} t + v_{i,t}.$$

where α_i is the country fixed effect and the standard error is clustered at the country level. We get $\hat{\beta}$ as -0.0242, with the standard error as 0.0076. Under the assumption that the OLS estimation of the slope of the Phillips curve has a downward bias, we prove that cyclical core inflation also has a downward trend between 2012 and 2019.

[14] IMF (2016) provides an update of the estimate. Most studies in the literature on the flattening of the Phillips curve focus on the period before and after 2000 rather than within the post-2000 period (Stock and Watson (2019) and Del Negro et al. (2020) among others).

V. Concluding Remarks

This paper documents salient facts regarding cyclical and non-cyclical parts of core inflation to shed light on the cause of dormant inflation processes across advanced economies between the global financial crisis and the COVID-19 pandemic.

The patterns we establish are consistent with the view that the intrinsic slope of the Phillips curve is significantly positive, implying that counter-cyclical movements of factors that are not changes in economic slack weakened the link between inflation and unemployment rate. In particular, we show that the non-cyclical part of core inflation fell persistently across AEs between 2012 and 2019, offsetting a recovery of the cyclical part of core inflation.

We find that the downward trend was broad-based across countries, sectors, goods, and services and not explained by global cost-push measures. We then argue that the more promising candidate to explain the disconnect puzzles should be changes in inflation expectations of firms rather than measurement errors. Lian and Sun (forthcoming) reaches a similar conclusion using a different approach.

This argument relates closely to that made by Coibion and Gorodnichenko (2015) that the expectation of firms was not fully anchored and rose between 2009 and 2011 due to rising oil prices. We, however, find that core non-cyclical inflation did not co-move well with oil prices. The inflation surge after the GFC concentrated in 2011, while the oil price rebound after the GFC started from 2009. The downward trend of core non-cyclical inflation was not reversed between 2016 and 2019, when oil price increased. Moreover, whether to include oil prices in a Phillips curve estimation does not affect the presence of a downward time trend for the non-cyclical part of core inflation.

Finally, our patterns also shed light on a difference between studies regarding whether missing disinflation after the global financial crisis existed (Coibion and Gorodnichenko (2015) and Hazell et al. (2020)). We argue that the proxy used by these studies to capture the inflation expectation of firms and whether they consider the rise in inflation in 2011 stand behind the different views.

References

Ball, Laurence M., and Sandeep Mazumder. 2011. "Inflation dynamics and the great recession." *NBER Working paper* No. w17044*,* National Bureau of Economic Research.

Ball, Laurence M., and Sandeep Mazumder. 2019. "The Nonpuzzling behavior of median inflation." *NBER Working paper* No. w25512. National Bureau of Economic Research.

Ball, Laurence M., Daniel Leigh, Prachi Mishra, and Antonio Spilimbergo. 2021. "Measuring US Core Inflation: The Stress Test of COVID-19." *NBER Working paper* No. w29609. National Bureau of Economic Research.

Ball, Laurence. 2006. "Has Globalization Changed Inflation?. " *NBER Working paper* No. w12687, National Bureau of Economic Research.

Benigno, Gianluca, Julian di Giovanni, Jan J. J. Groen, and Adam I. Noble, "A New Barometer of Global Supply Chain Pressures" Federal Reserve Bank of New York Liberty Street Economics, January 4, 2022, https://libertystreeteconomics.newyorkfed.org/2022/01/a-new-barometer-of-global-supply-chain-pressures/.

Blanchard, Olivier, Eugenio Cerutti, and Lawrence Summers. 2015. "Inflation and Activity – Two Explorations and their Monetary Policy Implications. " *IMF Working Paper* 15/230, International Monetary Fund, Washington, DC.

Candia, Bernardo, Olivier Coibion, and Yuriy Gorodnichenko. 2021. "The Inflation Expectations of US Firms: Evidence from a new survey." *NBER Working paper* No. w28836, National Bureau of Economic Research.

Celasun, Oya, Ava Hong, and Weicheng Lian. 2018. "What Has Held Core Inflation Back in Advanced Economies?." Box 1.2. of *World Economic Outlook,* April 2018, International Monetary Fund, Washington, DC.

Coibion, Olivier, Yuriy Gorodnichenko, and Rupal Kamdar. "The formation of expectations, inflation, and the Phillips curve." *Journal of Economic Literature* 56, no. 4 (2018): 1447-91.

Coibion, Olivier, and Yuriy Gorodnichenko. 2015. "Is the Phillips curve alive and well after all? Inflation expectations and the missing disinflation." *American Economic Journal: Macroeconomics* 7, no. 1 (2015): 197-232.

Del Negro, Marco, Michele Lenza, Giorgio E. Primiceri, and Andrea Tambalotti. 2020. "What's up with the Phillips Curve? " *NBER Working paper* No. w27003, National Bureau of Economic Research.

Del Negro, Marco, Aidan Gleich, Shlok Goyal, Alissa Johnson, and Andrea Tambalotti. 2022. "Drivers of Inflation: The New York Fed DSGE Model's Perspective." No. 20220301. Federal Reserve Bank of New York.

Dolmas, Jim, and Evan F. Koenig, 2019, "Two Measures of Core Inflation: A Comparison," https://ssrn.com/abstract=3494166 or http://dx.doi.org/10.20955/r.101.245-58.

Dolmas, Jim, 2005, "Trimmed Mean PCE Inflation," Federal Reserve Bank of Dallas Research Department Working Paper No. 0506

Forbes, Kristin. 2019. "Inflation dynamics: Dead, dormant, or determined abroad?" *NBER Working paper* No. w26496. National Bureau of Economic Research.

Gilchrist, Simon, Raphael Schoenle, Jae Sim, and Egon Zakrajšek. "Inflation dynamics during the financial crisis." *American Economic Review* 107, no. 3 (2017): 785-823.

Hazell, Jonathon, Juan Herreño, Emi Nakamura, and Jón Steinsson. 2020. "The slope of the Phillips curve: evidence from US states." *NBER Working paper* No. w28005, National Bureau of Economic Research.

Heise, Sebastian, Fatih Karahan, and Ayşegül Şahin. 2022. "The Missing Inflation Puzzle: The Role of the Wage-Price Pass-Through." *Journal of Money, Credit and Banking* 54, no. S1: 7-51.

Hong, Gee Hee, Zsóka Kóczán, Weicheng Lian, and Malhar Nabar. 2018. "More Slack than Meets the Eye? Recent Wage Dynamics in Advanced Economies." *IMF Working paper* 18/50, International Monetary Fund, Washington, DC.

IMF. 2016. "Global Disinflation in an Era of Constrained Monetary Policy." Chapter 3 of *World Economic Outlook,* October 2016. Washington, DC: International Monetary Fund.

Jorgensen, Peter Lihn, Kevin J. Lansing. 2019. “Anchored Inflation Expectations and the Flatter Phillips Curve,” Federal Reserve Bank of San Francisco Working Paper 2019-27. https://doi.org/10.24148/wp2019-27

Kumar, Saten, Hassan Afrouzi, Olivier Coibion, and Yuriy Gorodnichenko. 2015. “Inflation targeting does not anchor inflation expectations: Evidence from firms in New Zealand.” *NBER Working paper* No. w21814*,* National Bureau of Economic Research.

Lian, Weicheng, and Xiaohui Sun. “Global Phillips Curve and Global Disinflation”, working paper, forthcoming.

Mahedy, Tim, and Adam Shapiro. 2017. "What’s Down with Inflation?." *FRBSF Economic Letter* 35 (2017).

Mavroeidis, Sophocles, Mikkel Plagborg-Møller, and James H. Stock. 2014. "Empirical evidence on inflation expectations in the New Keynesian Phillips Curve." *Journal of Economic Literature* 52, no. 1 (2014): 124-88.

McLeay, Michael, and Silvana Tenreyro. 2020. "Optimal inflation and the identification of the Phillips curve." *NBER Macroeconomics Annual* 34, no. 1 (2020): 199-255.

Obstfeld, Maurice. 2019. "Global dimensions of US monetary policy. " *NBER Working paper* No. w26039*,* National Bureau of Economic Research.

Rognlie, Matthew. 2019. “Comment on `Optimal Inflation and the Identification of the Phillips Curve’." *NBER Working paper* No. c14247, National Bureau of Economic Research.

Rogoff, Kenneth. 2003. "Globalization and global disinflation." *Economic Review-Federal Reserve Bank of Kansas City* 88, no. 4 (2003): 45-80.

Stock, James H., and Mark W. Watson. 2019. "Slack and Cyclically Sensitive Inflation." *NBER Working paper* No. w25987, National Bureau of Economic Research.

A. Data Sources, Variable Definitions, and Country Sample

This section explains how the data was constructed for this paper, including the details of the construction of the key variables. Table A.1, A.2, and A.3 provide the summaries.

1. CPI components

We get the price index of CPI components and most of their weights at the country level and at the metropolitan statistical area level from the Eurostat, Haver Analytics, and OECD Statistics. We get the CPI weights of Bangladesh and China from the CEIC.

2. Unemployment Gap, and Variables used in Phillips Curves Analyses

The unemployment rate and NAIRU come from OECD statistics. The inflation expectation comes from the Consensus Forecast database. We construct output gap using real GDP from the World Economic Outlook dataset.

3. Country sample

The country sample includes Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

4. Definition of Goods and Services

Within each COICOP component, we further differentiate between goods and services components. Given the breakdown of the consumption basket varies across data sources, Table A.2 reports a mapping between a detailed breakdown and its classification into good (G), services (S), or hybrid (GS). We exclude components classified as GS in the exercise behind Figure 5.

Table A.1. Data Sources

Sources	*Indicators*
Eurostat	Headline inflation, Core inflation, CPI components, CPI weights
Haver Analytics	Headline inflation, Core inflation, CPI components, CPI weights
IMF, World Economic Outlook database	PPPGDP
OECD Stat	Headline inflation, core inflation, CPI components, CPI weights, Unemployment rate, Equilibrium unemployment rate (Non-accelerating inflationary rate of unemployment)

Table A.2. CSI Weights, Correlation between Cyclical Slack Measure and Inflation Measures: 1984-2019, PCE Components

	CSI Weights				Correlation between cyclical slack measure and:	
Component	1	2	3	4	4Q change in 4Q inflation	Bandpass inflation
Components with positive weights in CSI						
1. Housing excluding gas & electric utilities	0.496	0.56	0.51	0.20	0.40	0.62
2. Food and beverages purchased for off-premises consumption	0.137	0.17	0.03	0.10	0.42	0.58
3. Other services	0.103	0.08	0.00	0.16	0.16	0.13
4. Recreation services	0.100	0.08	0.02	0.17	0.27	0.39
5. Recreational goods and vehicles	0.087	0*	0.11	0.12	0.25	0.35
6. Food services and accommodations	0.033	0.08	0.28	0.19	0.45	0.67
7. Final cons. exp. of nonprofits (NPISHs)	0.028	0*	0.00	0.03	0.15	0.31
8. Gas & electric utilities	0.016	0.02	0.03	0.01	0.13	0.24
Components with almost zero weights in CSI						
9. Furnishings and durable household equipment	0.000	0.00	0.00	0.00	0.08	0.31
10. Other durable goods	0.000	0.00	0.00	0.00	0.08	0.17
11. Transportation services	0.000	0.00	0.00	0.00	0.01	0.03
12. Other nondurable goods	0.000	0.00	0.00	0.01	-0.03	-0.11
13. Clothing and footwear	0.000	0*	0.00	0.00	-0.09	-0.02
14. Gasoline and other energy goods	0.000	0.00	0.00	0.00	-0.10	-0.06
15. Health care	0.000	0.00	0.00	0.00	-0.11	-0.04
16. Financial services and insurance	0.000	0*	0.01	0.00	-0.17	-0.12
17. Motor vehicles and parts	0.000	0.00	0.00	0.01	-0.33	-0.27

Notes: This table replicates Table 4 and part of Table 5 of Stock and Watson (2019). The components are sorted based on their CSI weights in the categorty "1", and then by the correlation between cyclical slack measure and 4Q change in 4Q inflation, and that between cyclical slack measure and bandpass inflation. According to Stock and Watson (2019), CSI weights are estimated by nonlinear least squares estimation of the regression in Equation (3) of the paper. The CSI weights are as follows: 1. Benchmark (see the text of the paper), 2. Excludes four poorly measured sectors (see Table 3 of the paper), 3. Uses bandpass inflation in place of yoy inflation, 4. Imposes maximum weight of 0.20. *Restricted to equal zero.

Table A.3 Classifications of CPI Components into Goods vs. Services

Classifications	CPI Components Names	Classifications	CPI Components Names
G	Alcoholic Bev, Tobacco Prod & Recreational Cannabis	GS	All-Inclusive Holiday Packages
G	Alcoholic Beverages, Tobacco and Narcotics	GS	Audio, Visual & Computing Equip & Services
G	Apparel and Footwear	GS	Dental Services
G	Audio-visual, photographic and information processing equipment	GS	Education Not Definable by Level
G	Bedding	GS	Furniture and furnishings, carpets, and other floor coverings
G	Books & Other Reading Materials	GS	Goods and Services for Routine Household Maintenance
G	Cellular Phones	GS	Home Entertainment Equipment/Parts/Services
G	Clothing and Footwear	GS	Hospital Services
G	Domestic Non-durables	GS	Household Appliances & Nonelectrical Equipment
G	Domestic Utensils	GS	Household Appliances, Fittings & Repairs
G	Educational Books & Supplies	GS	Information & Information Processing
G	Equipment for Sport, Camping and Open-Air Recreation	GS	Maintenance and Repair of the Dwelling
G	Equipment to Receive/Reproduce Sound & Pictures	GS	Medical Services & Paramedical Services
G	Fixed Telephone Equipment	GS	Medicines & Health Fortification
G	Furniture, Carpets & Household Furnishing Items	GS	Other Household Goods and Services
G	Games, Toys & Hobby Goods	GS	Other Miscellaneous
G	Garden Products, Plants and Flowers	GS	Personal Care Services
G	Glassware, Tableware and Household Utensils	GS	Pets, Pet Products and Services
G	Goods and Services for Sport, Camping & Recreation	GS	Postal Services
G	Health Care Goods	GS	Pre-Primary, Prim & Second Edu
G	House & Garden Tools and Equipment	GS	Private Transportation
G	Household Cleaning Products	GS	Purchase & Operation of Recreational Vehicles
G	Household Durables	GS	Purchase/Leasing/Rental of Passenger Vehicles
G	Household Equipment	GS	Secondary Education
G	Household Supplies	GS	Services Related to Household Furnishings/Equipment
G	Household Textiles	GS	Telecommunication Equipment and Services
G	Housekeeping Supplies	GS	Telephone and Telefax Equipment
G	Household Appliances, Utensils and Tools	GS	Tertiary Education
G	Information Processing Equipment	GS	University Education
G	Interior Furnishings	GS	Water supply and miscellaneous services relating to the dwelling
G	Letters	S	Actual Rentals for Housing
G	Major Durables for Outdoor Recreation	S	Bundled Telecommunication Services
G	Major household appliances whether electric or not and small electric household appliances	S	Child Care and Housekeeping Services
G	Materials for the maintenance and repair of the dwelling	S	Communications
G	Medical Care Commodities	S	Council Tax and Rates
G	Medical Products, Appliances and Equipment	S	Domestic services and household services

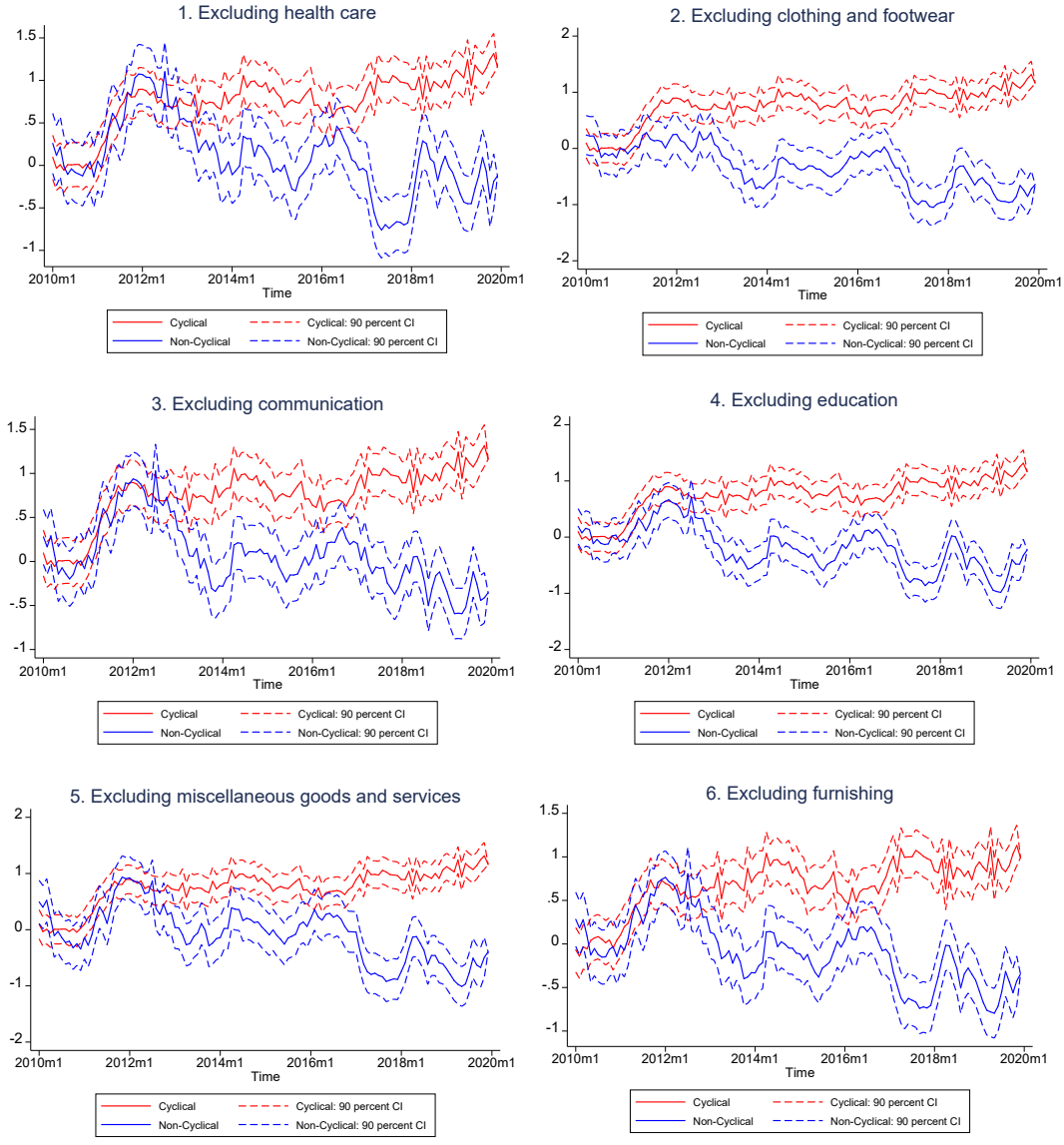
G	Misc Personal Goods	S	Education Services Not Definable by Level
G	Mobile Telephone Equipment	S	Financial & Insurance Services
G	Motor Vehicle Parts and Equipment	S	Forwarding Charges
G	Musical Instruments & Major Durables for Indoor Recr	S	Health Care Services
G	New and Used Vehicles	S	Holiday Travel and Accommodation
G	Newspapers, Books and Stationery	S	Home Repair & Maintenance
G	Non-durable household goods	S	Hospital Services
G	Other Durables for Recreation and Culture	S	Hotels and Restaurants
G	Other Recreational Goods	S	Household Operations
G	Other recreational items and equipment, gardens and pets	S	Household Services
G	Paper, Plastic and Foil Supplies	S	Internet Access Provision Services
G	Personal Care Products	S	Lesson Fees
G	Personal Care Supplies and Equipment	S	Maintenance & Repair of Transport Equipment
G	Personal Effects	S	Maintenance/Repair of Other Major Durable for Recreation/Culture
G	Pets and Related Products	S	Medical Services
G	Pets including Semidurables and Nondurables	S	Medical, Dental and Hospital Services
G	Photographic, Cinematographic & Optical Equipment	S	Miscellaneous Personal Services
G	Postcards	S	Motor Vehicle Fees
G	Print Products, Stationery and Drawing Materials	S	Motor Vehicle Insurance
G	Purchase of Vehicles	S	Motor Vehicle Maintenance & Repair
G	Radio and Television Sets and the Like	S	Operation of Automotive Vehicles
G	Reading Material excluding Textbooks	S	Other Recreation, Sporting & Cultural Services
G	Reception, Recording Eqpt/Sound & Picture Reproduction	S	Other Services for Personal Transport Equipment
G	Recording Media	S	Other Services in Respect of Personal Transport Eqpt
G	Recreational Durables	S	Other Services in respect of personal transport equipment
G	Recreational Eqpt/Services ex Recreational Vehicles	S	Other Services Relating to the Dwelling nec
G	Recreational Goods	S	Other Services, nec
G	Recreational Reading Materials	S	Out-Patient Services
G	School Textbooks & Reference Books for Students	S	Owned Accommodation
G	Sound, Picture and Other Data Storage Media	S	Owner Occupiers' Housing Costs
G	Spare parts and accessories for personal transport equipment	S	Passenger Transport Services
G	Sporting Goods	S	Personal Care Services
G	Telephone and Telefax Equipment	S	Postage & Delivery Services
G	Tobacco & Smoking Products	S	Private Transportation
G	Toilet Articles	S	Public Transportation
G	Tools/Hardware/Outdoor Eqpt/Supplies	S	Recreational and Cultural Services
G	Transport Equipment	S	Refuse Collection
G	Vehicle Purchases	S	Rent
G	Video and Audio	S	Rented Accommodation

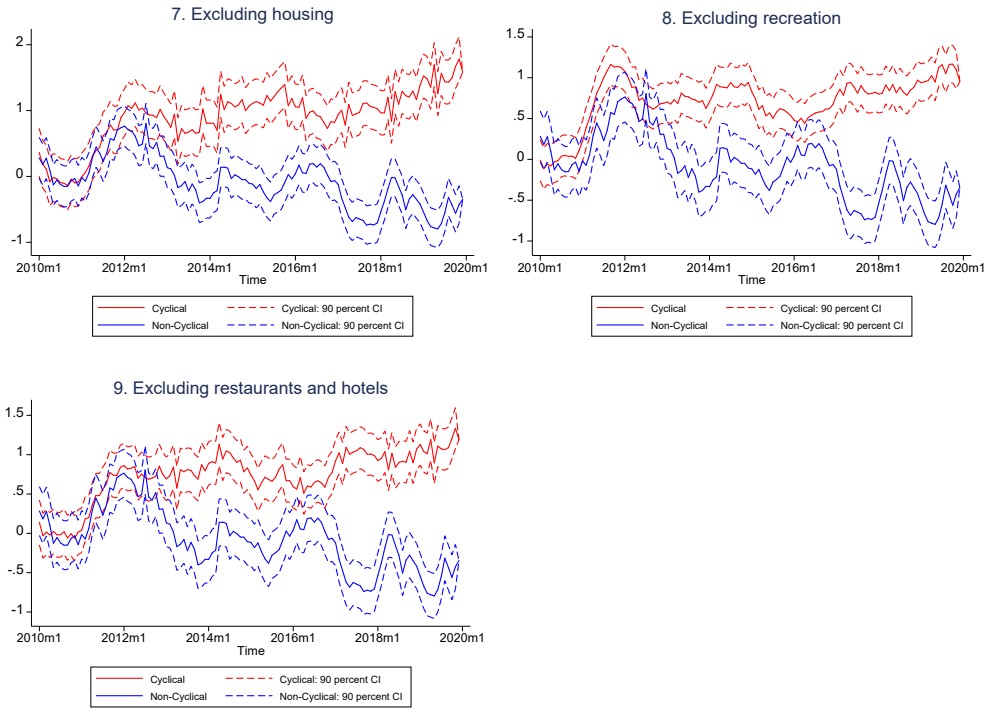
			Repair of Audio-Visual/Photographic/Info Process
G	Water Supply	S	Eqpt
G	Window & Floor Coverings & Other Linens	S	Repair of household appliances
		S	Restaurants and Hotels
		S	School Fees
		S	Service Charges for Repairs & Maintenance
			Services for the maintenance and repair of the
		S	dwelling
		S	Services of Preprimary and Primary Education
		S	Services of Secondary Education
		S	Services of Tertiary Education
			Services Related to Household
		S	Furnishings/Equipment
		S	Sewage Collection
		S	Social Protection Services
		S	Sports Participation
		S	Telephone and Telefax Services
		S	Transport Services
		S	Travel Services
		S	Tuition, Other School Fees & Child Care
		S	Veterinary and Other Services for Animals
			Water Supply & Miscellaneous Services for the
		S	Dwelling
		S	Wired Telephone Services
		S	Wireless Telephone Services

B. Robustness of Patterns to Excluding First-Digit COICOP Components

This section reports the robustness of the divergence between core cyclical inflation and core non-cyclical inflation and the downward trend of core non-cyclical inflation to the exclusion of one-digit COICOP components.

Figure B1. Core Cyclical Inflation and Core Non-Cyclical Inflation: Excluding First-Digit COICOP Components





Sources: Haven Analytics, Euro stat, the OECD stat, and authors' calculation.

PUBLICATIONS

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