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Low Inflation in Advanced Economies: Facts and Drivers

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Abstract

Since the global financial crisis, core inflation has been persistently below target in most advanced economies. Recently, it has weakened further in several advanced economies despite gradually diminishing slack. This note reviews recent developments in core inflation across advanced economies and identifies distinctive patterns across regions. In many advanced economies outside of the United States, the decrease in core inflation started in 2016 and was driven primarily by goods prices—most likely because of lower export prices from China in 2016 and past exchange rate appreciations. In the United States, however, the decline in core inflation began in 2017 and has been driven mostly by service prices rather than goods prices. We estimate that roughly two-thirds of the softening in US core inflation may be due to idiosyncratic factors that are unlikely to persist, while the remaining one-third may be attributable to more persistent factors. We then examine the extent to which the persistent weakness in inflation after the global financial crisis can be explained by common factors across advanced economies. Our results suggest that global factors do not play much of a role in influencing domestic core inflation dynamics but that they remain important determinants of total inflation, acting mainly through the goods inflation channel—particularly through energy prices. Finally, we briefly investigate the relationship between economic slack and inflation. We find that the relationship between the output gap and core inflation remains positive, albeit modest, in advanced economies and that a significant share of the post-crisis weakness in inflation has been driven by domestic economic slack. In addition, we find that the relationship between the output gap and inflation is more evident with core services inflation than core goods inflation.

Bank topics: Inflation and prices; International topics
JEL codes: E0, E31, F0

Résumé

Depuis la crise financière mondiale, l'inflation fondamentale s'est maintenue en deçà de la cible dans la plupart des économies avancées. Dernièrement, elle s'est inscrite en baisse dans plusieurs de ces économies, malgré la diminution graduelle de la marge de capacités excédentaires qui s'y opère. Dans cette note, nous examinons les évolutions récentes de l'inflation fondamentale dans les économies avancées et distinguons des dynamiques particulières selon les régions. Dans bon nombre des économies avancées hors États-Unis, le recul de l'inflation fondamentale, qui se manifeste depuis 2016, résulte principalement de l'évolution des prix des biens — vraisemblablement en raison de la baisse des prix à l'exportation de la Chine et de l'appréciation passée des taux de change. Aux États-Unis, par contre, la baisse de l'inflation fondamentale s'est amorcée en 2017 et tient pour l'essentiel au recul des prix des services et non des biens. Nous estimons qu'environ les deux tiers du fléchissement de l'inflation fondamentale dans ce pays pourraient être attribuables à des facteurs idiosyncratiques peu susceptibles de persister, et le tiers restant, à des facteurs plus durables. Nous analysons ensuite dans quelle mesure la faiblesse persistante de l'inflation depuis la crise peut s'expliquer par des facteurs

communs à l'ensemble des économies avancées. Il se dégage de nos résultats que les facteurs mondiaux ne semblent pas jouer un rôle notable dans la dynamique de l'inflation fondamentale mais demeurent d'importants déterminants de l'inflation globale par leurs effets sur l'accroissement des prix des biens, notamment de l'énergie. Enfin, nous étudions brièvement la relation entre les capacités excédentaires au sein de l'économie et l'inflation. Nous constatons que la relation entre l'écart de production et l'inflation fondamentale, bien que ténue, demeure positive dans les économies avancées et que les capacités excédentaires présentes dans les économies seraient responsables d'une part non négligeable de la faiblesse de l'inflation enregistrée depuis la crise. De plus, nous observons que le lien entre l'écart de production et l'inflation est plus marqué dans le cas des prix des services compris dans la mesure de l'inflation fondamentale que dans celui des prix des biens pris en compte dans cette mesure.

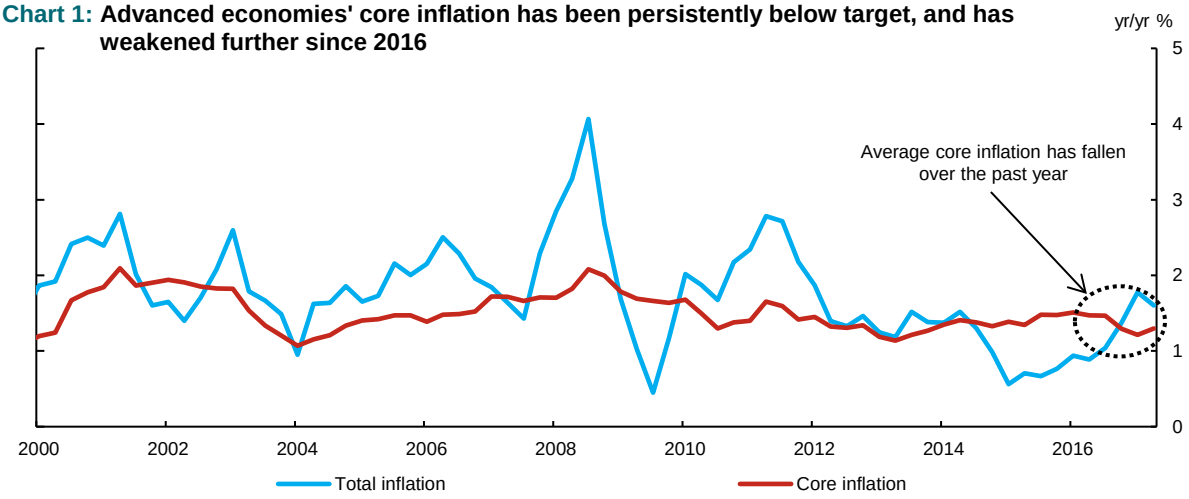
Sujets : Inflation et prix; Questions internationales
Codes JEL : E0, E31, F0

1. Introduction

Core inflation has been persistently below target in most advanced economies since the global financial crisis. And it has weakened further in several advanced economies since 2016 despite gradually diminishing slack. Total inflation has also been subdued over most of this period, though much of its volatility since the crisis has been driven by energy price fluctuations (**Chart 1**).

In this note, we take multiple approaches to help understand the dynamics driving core inflation. In Section 2, we delve into recent country-level developments in core inflation to identify any similarities in timing and sectoral drivers across advanced economies. In Section 3, we analyze the existence of any common underlying global trends in inflation across advanced economies. And finally, in Section 4, we examine the role of the domestic output gap and other potential drivers (such as inflation expectations, exchange rate movements, etc.) of inflation trends.

Chart 1: Advanced economies' core inflation has been persistently below target, and has weakened further since 2016



Notes: "Total" measured as headline personal consumption expenditure (PCE; US) or consumer price index "(CPI; others)" inflation; "core" based on PCE and CPI exclusion measures ("western core" for Japan). Aggregate calculated as a simple average of inflation in the United States, euro area, Japan, United Kingdom, Australia, Sweden, Canada, Denmark, New Zealand and Norway. Japan data exclude impact of 2014 tax hike.

Sources: National accounts via Haver Analytics, Bank of Canada calculations

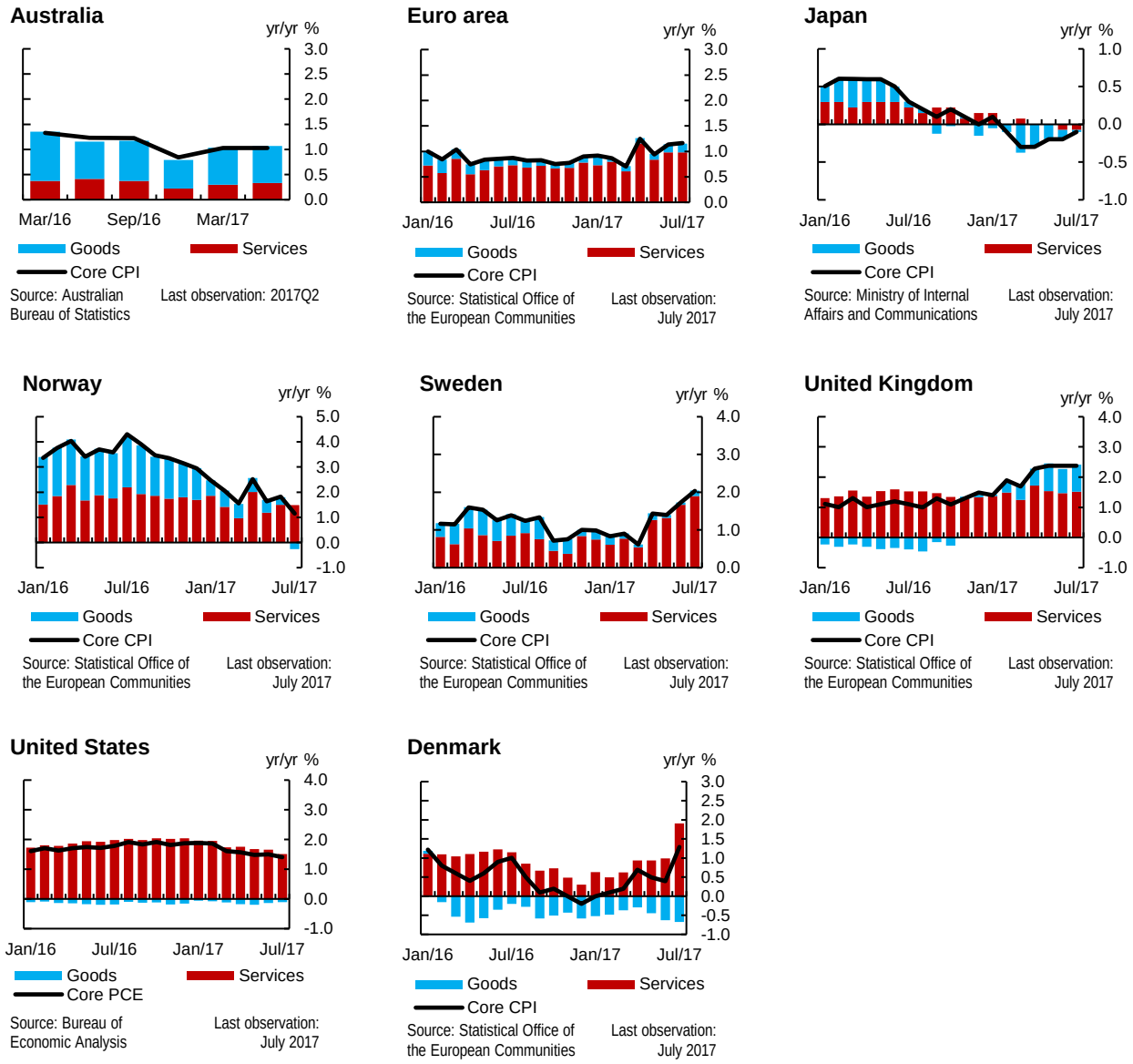
Last observation: 2017Q2

2. Recent Developments in Core Inflation

While the very recent weakening in 2017 appears to be specific to the United States, core inflation had begun to slow in several other advanced economies in early 2016, despite the ongoing recovery of economic activity (**Chart 2**). This decline appears to have stabilized or reversed in 2017 in the majority of cases (i.e., Japan, Australia, Sweden and Denmark; Norway is the exception, where the decline in core

inflation that started in 2016 has continued in 2017[1]). In the euro area, core inflation remained relatively unchanged over 2016, though it too has picked up slightly in 2017.

Chart 2: The decline of core inflation has stabilized or reversed in 2017 in most cases



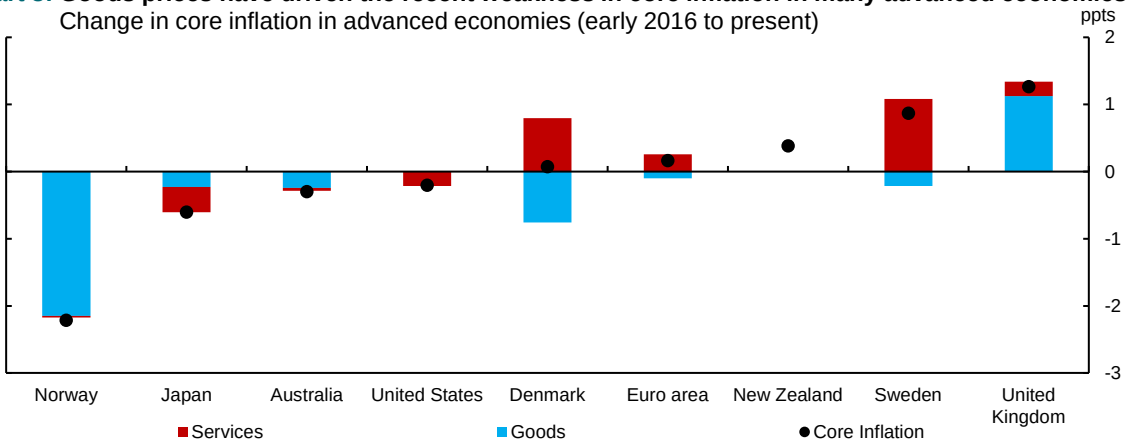
Notes: Charts report personal consumption expenditure inflation for the United States and consumer price index inflation for other countries. Definitions of "core goods" and "core services" differ slightly across countries, and have been estimated by Bank of Canada staff when not provided directly by national statistics agencies. Japan data are estimated based on the "western core" measure, which excludes energy and food.

[1] In Norway, Norges Bank is explicitly keeping the key policy rate higher than what macroeconomic conditions would imply because of financial stability considerations (see, for example, Norges Bank 2017, page 35).

The decrease in core inflation since 2016 was driven primarily by goods prices in most cases (**Chart 3**). This is likely due to two factors weighing on imported goods prices: subdued export prices in emerging market trading partners and country-specific exchange rate movements.

Chart 3: Goods prices have driven the recent weakness in core inflation in many advanced economies

Change in core inflation in advanced economies (early 2016 to present)



Notes: Breakdown of core inflation by goods and services not available for New Zealand. Chart reports personal consumption expenditure inflation for the United States and consumer price index inflation for other countries. Definitions of "core goods" and "core services" differ slightly across countries, and have been estimated by Bank of Canada staff when not provided directly by national statistics agencies. Japan data are estimated based on the "western core" measure, which excludes energy and food. The latest available data are from 2017Q2 for Australia and New Zealand, and July 2017 for other countries.

Sources: National Accounts via Haver Analytics, Bank of Canada calculations

- Downward pressure on goods prices from emerging markets may have contributed to some of the recent cyclical weakness in import prices, but this is likely easing.[2] In particular, Chinese export price inflation weakened in late 2015 through much of 2016, and only picked up in early 2017 (**Chart 4**). However, as export prices in China have been stabilizing recently, downward price pressure from Chinese export prices is likely to be minimal in coming months.[3]

[2] This cyclical effect is distinct from the structural impact of globalization on advanced economies' disinflation. This structural impact was at its peak during the late 1990s and early 2000s when imports from emerging markets were steadily growing as a share of advanced economies' GDP.

[3] However, if there are lags between exports from China arriving and being sold in advanced economies, low export prices in 2016 may continue to exert some downward pressure on advanced economy inflation.

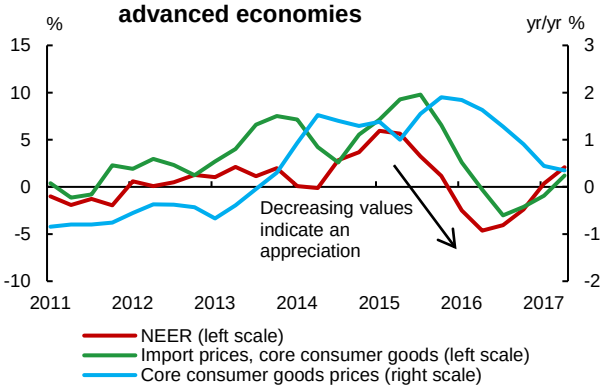
Chart 4: Advanced economies' imported goods price inflation has tracked China's exported goods price inflation in recent years

Notes: The global price index of Chinese exports is calculated as the product of China's renminbi export price index and the nominal effective exchange rate. Import prices are calculated as a simple average across Australia, the euro area, Japan, Norway and Sweden.

Sources: China Customs and JP Morgan via Haver Analytics

Last observation: Exports, July 2017; imports, 2017Q2

Chart 5: Core consumer goods price inflation has followed exchange rate movements and imported goods inflation in several advanced economies



Notes: Calculated as a simple average of countries that experienced nominal effective exchange rate appreciation (NEER) from 2015 to 2016, followed by depreciation. The selected countries are Australia, the euro area, Japan, Norway and Sweden.

Source: National sources via Haver Analytics

Last observation: 2017Q1

- Past exchange rate appreciation may have also contributed to weak imported goods inflation in some economies. **Chart 5** shows that advanced economies experienced declining goods price inflation starting around early to mid-2016, following exchange rate appreciations in 2015 (i.e., Australia, the euro area, Japan, Norway and Sweden). However, the decline in import price inflation slowed or reversed in 2017, perhaps reflecting different degrees of subsequent depreciation.[4]

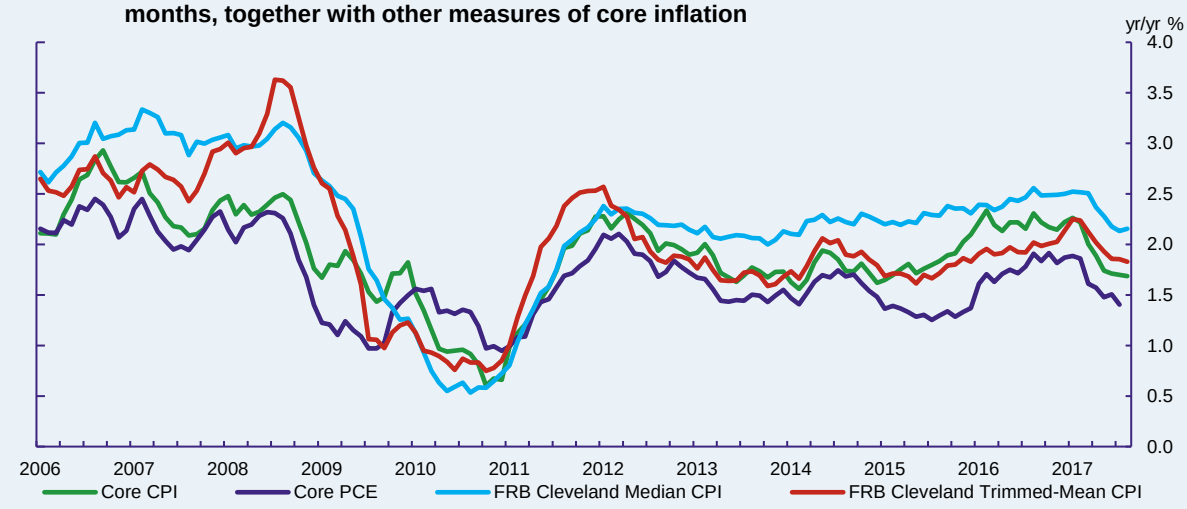
In the United States, unlike most other advanced economies, core inflation increased in 2016 before its very recent decline driven mostly by service prices rather than goods (see **Box 1**). Around two-thirds of this recent deceleration is due to idiosyncratic factors (e.g., financial services, telecommunications, medical care commodities, etc.) that are not likely to persist.

[4] One exception to this pattern is the United States, where exchange rate pass-through to import prices is typically lower than in other countries because of the high share of trade that is invoiced in US dollars. This is likely one of the reasons that core consumer goods inflation has remained fairly stable for the past several years, despite the US dollar appreciation and subsequent depreciation. The other main exception is the United Kingdom, where steady depreciation from late 2015 to late 2016 exerted positive inflationary pressure on import prices and likely contributed to the pickup in core consumer goods inflation since mid-2016.

Box 1: Explaining the recent slowdown in US core inflation

Since the beginning of 2017, core personal consumption expenditure (PCE) inflation has slowed markedly in the United States, decelerating 0.5 percentage points from January 2017 to July 2017. The deceleration is also evident in other alternative measures of core inflation (**Chart B1**).

Chart B1: Core personal consumption expenditure and consumer price index have softened in recent months, together with other measures of core inflation



Sources: US Bureau of Economic Analysis, US Bureau of Labor Statistics, Federal Reserve Bank (FRB) of Cleveland, via Haver Analytics

Last observation: PCE, July 2017; CPI-based measures, August 2017

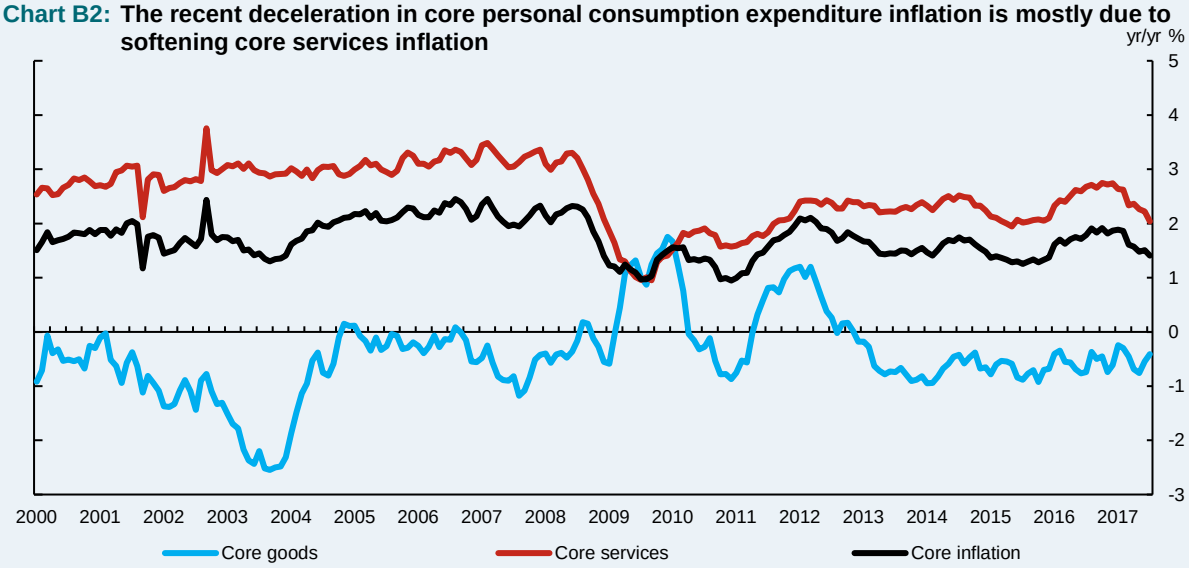
This recent deceleration is almost entirely a result of a softening in core services prices, which accounted for 0.45 percentage points of the recent slowdown. Core goods pulled down core inflation by only around 0.05 percentage points.[1]

Core services inflation began rising at the beginning of 2016, as slack in the US economy was gradually diminishing. But this trend has recently reversed, despite a continued closing of the US output gap (**Chart B2**).

In contrast, core goods inflation has been historically low or negative and has remained so. This explains less than 10 per cent of the recent deceleration in core inflation.

[1] While medical care commodities, apparel prices and, to a lesser extent, motor vehicle prices have contributed to the deceleration of inflation since the start of the year, other goods prices have accelerated. These include recreational goods (including video/audio equipment and sporting equipment), tobacco, magazines, newspaper and stationery.

Chart B2: The recent deceleration in core personal consumption expenditure inflation is mostly due to softening core services inflation



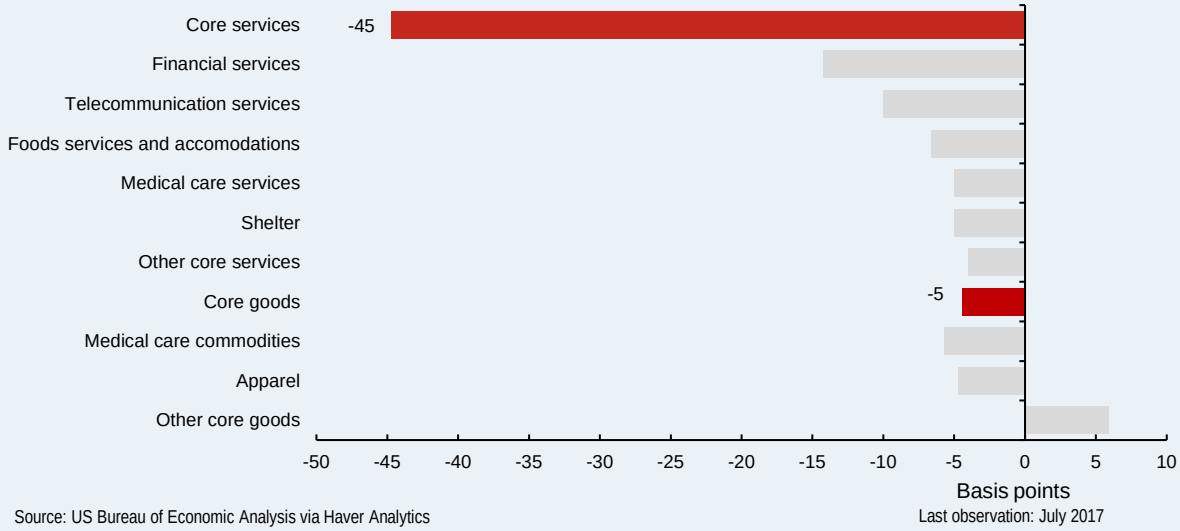
Source: US Bureau of Economic Analysis via Haver Analytics

Last observation: July 2017

A decomposition of the recent slowdown suggests that roughly two-thirds of the softening in core inflation is due to idiosyncratic factors, such as deceleration in financial services perhaps resulting from methodological issues, a sudden drop in prices in the telecommunication sector, and transitory weakness in medical care commodities. We expect these factors to dissipate over time (**Chart B3**). For example, telecommunication prices have already stabilized in the month-over-month space.

However, the downward pressure on price growth in some other categories, such as shelter and medical care services, is unlikely to dissipate in the near term.

Chart B3: Contributions to slowdown in year-over-year core personal consumption expenditure from January 2017 to July 2017



Source: US Bureau of Economic Analysis via Haver Analytics

Last observation: July 2017

We still expect inflation to rise gradually towards target as the tight labour market increases wage inflation, and the effects of idiosyncratic factors dissipate over time. As the analysis in Section 4 below shows, inflation in the services sector is historically more closely related to domestic economic slack. Moreover, the recent depreciation in the US dollar since early 2017 should provide some upward pressure to US import and goods prices as well. The continuation of weakness in some categories, however, suggests a downside risk to our inflation outlook.

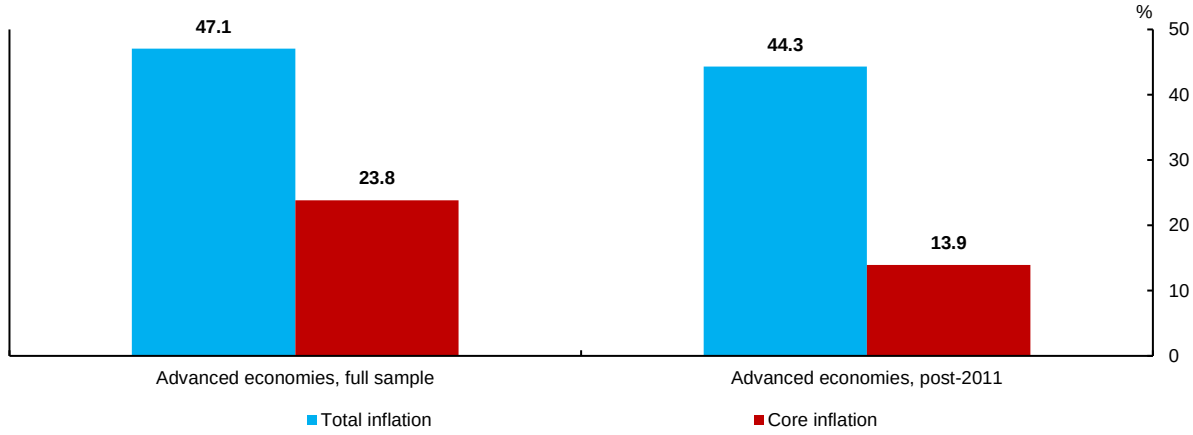
3. Common factors in advanced economy inflation

This section examines the extent to which the persistent weakness in inflation after the global financial crisis can be explained by common factors across advanced economies. Using a static factor model, we estimate the first common factor of total and core inflation and obtain the share of variation explained by this common factor. Our analysis covers a sample of 11 advanced economies (10 member countries of the Organisation for Economic Co-operation and Development (OECD), and the euro area as a whole) over the period 1997Q1 to 2017Q2.

Our main result is that common trends explain a significant portion of the variation in total inflation, but they play a smaller role in explaining national core inflation dynamics.

- For the full sample period, 1997Q1 to 2017Q2, the common factor explains 47.1 per cent of the variation observed in total inflation using the static factor model (**Chart 6**). For a more recent sample period covering 2012Q1 to 2017Q2, the common factor remained important, explaining 44.3 per cent of the variation in total inflation. A breakdown of the explained variation across the 11 countries highlights that the explanatory power of the common factor is uniformly representative of all countries in the post-2011 sample (**Table A1** in **Appendix 1**).

Chart 6: Common factors continue to explain a notable share of variation in advanced economy total inflation but play a smaller role in explaining core inflation dynamics



Notes: The factor for total and core inflation is estimated using standardized values over two samples: 1997Q1–2017Q2 and 2012Q1–2017Q2.

Sources: Organisation for Economic Co-operation and Development via Haver Analytics and Bank of Canada calculations

For core inflation, common trends play a far less important role than for total inflation.

- Estimated over the full sample (1997Q1 to 2017Q2), the common factors explain 23.8 per cent of variation in core inflation. This proportion decreases to 13.9 per cent in the post-2011 period. Additionally, the common factor for core inflation mainly explains variation in the euro area, Korea, New Zealand, Australia and the United States post-2011 (**Table A1**). The resulting underlying common trends for core inflation, therefore, are more representative of a select few countries and do not evenly account for variation across our country sample.

Chart 7a: **There is a strong co-movement between the first common factors of total and goods inflation**

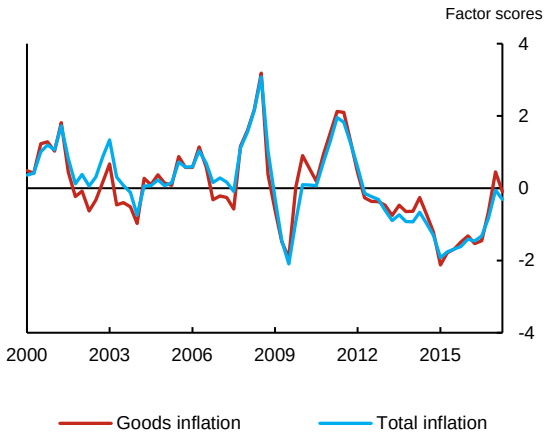
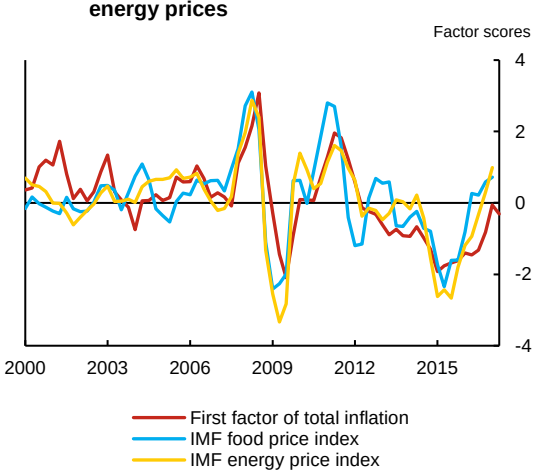


Chart 7b: **The importance of the common factor of total inflation likely stems from commodity prices channel of goods inflation, especially energy prices**



Notes: The series are standardized by subtracting the country-specific mean and dividing by the country-specific deviation at each data point. Factor analysis for goods inflation excludes Denmark. The factor is estimated using standardized values of inflation over the period 1997Q1–2017Q2.

Sources: Organisation for Economic Co-operation and Development via Haver Analytics, International Monetary Fund and Bank of Canada calculations

Last observation: Inflation, 2017Q2; commodity price indices, 2017Q1

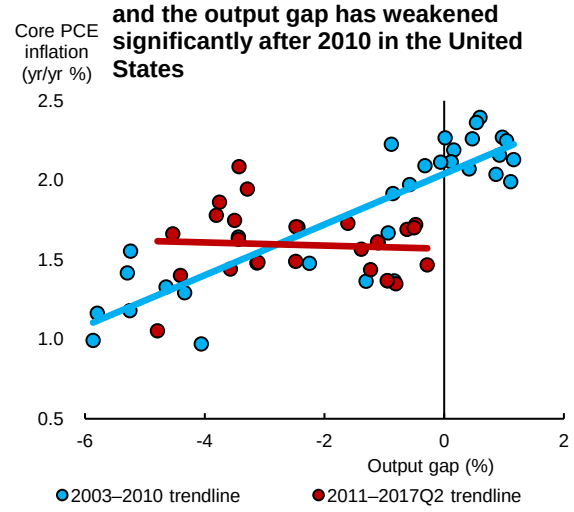
The relative strength of the common factor in explaining variation in total inflation is acting through the goods inflation channel, particularly via energy prices (**Chart 7a** and **Chart 7b**). The variation in core and services inflation explained by common factors remains small, with country-specific factors being more influential for national inflation dynamics.

4. Domestic Economic Slack and Other Key Drivers

In this section, we briefly investigate how much of the post-crisis weakness is driven by the existing economic slack and whether the impact of slack manifests more in service prices than in goods prices.

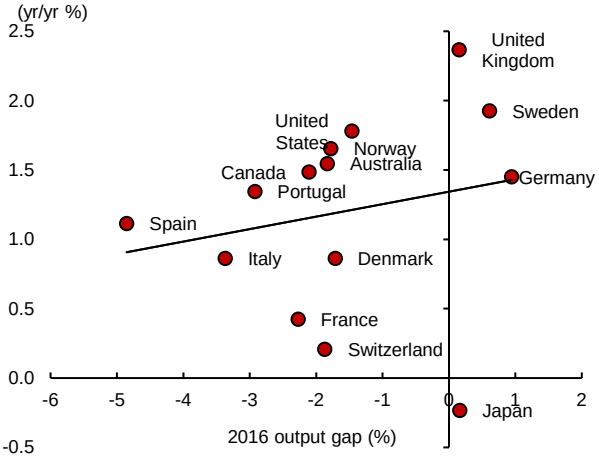
In some economies, such as the US, the existence of the Phillips curve relationship has been questioned, since the relationship between core inflation and the output gap weakened significantly after 2010 (**Chart 8**). A look at advanced economies' 2016 output gap and more recent quarter core inflation data, however, suggests that there is a positive, albeit modest, relationship between economic slack and inflation (**Chart 9**).

Chart 8: The relationship between core inflation and the output gap has weakened significantly after 2010 in the United States



Sources: US Bureau of Economic Analysis via Haver Analytics and Bank of Canada

Chart 9: The relationship between the output gap and core inflation remains positive in advanced economies



Sources: Organisation for Economic Co-operation and Development via Haver Analytics and Bank of Canada calculations

To further examine this question, we first estimate a simple Phillips curve augmented with relative import price inflation, oil prices and inflation expectations.[5] Inflation expectations are modelled as partly backward-looking (using lagged inflation), and partly forward-looking (using long-term expectations). We find a positive, albeit modest, relationship between economic slack and inflation in the United States, euro area and Japan.[6] See **Appendix 2** for details.

Using the same specification as for core inflation, we then estimate separate Phillips curves for core goods and services.[7] We find that the relationship between the output gap and inflation is more evident with core services inflation (**Chart 10**) than core goods inflation (**Chart 11**).[8]

[5] Short-term measures of inflation expectations were not statistically significant once we controlled for past inflation and long-term inflation expectations. This is consistent with Abdih, Balakrishnan and Shang (2016).

[6] Ordinary least squares (OLS) estimates for the Phillips curve may be biased because of endogeneity if the true data generating process has important relationships between the output gap, inflation and interest rates. Estimating a system of equations (IS curve, Taylor Rule and Phillips curve) can potentially address this endogeneity problem. Preliminary findings by Bank staff suggest Phillips curve relationships are meaningful over the full sample for the United States, euro area and Japan.

[7] In the United States, core services inflation declined through the 1990s from close to 5 per cent to about 2 per cent, climbed again in the 2000s to reach 3.4 per cent before the financial crisis, but then fell significantly during the Great Recession. It has recovered since, but now at around 2 per cent, it remains significantly below past levels. Core goods inflation, on the other hand, has often been negative over the last 20 years, likely reflecting the impact of global pressures.

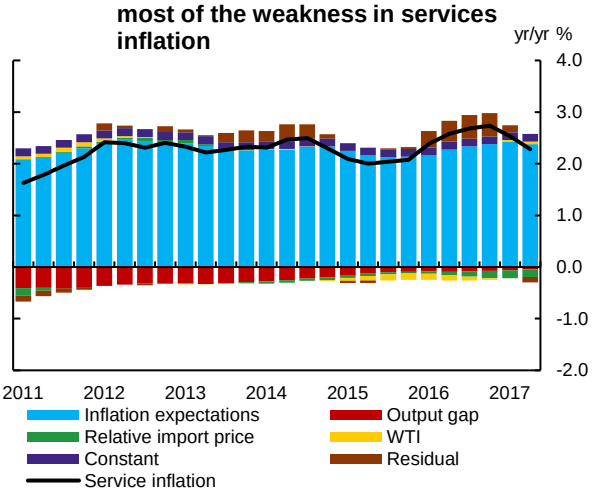
[8] Similar results were obtained using the unemployment gap rather than the output gap.

Additional details on our main findings are as follows:

- The output gap coefficients are larger for services inflation than for goods inflation in the United States and euro area:
    - In the core services models, the size of the output gap coefficients increases by about 40 per cent for the United States and 70 per cent for the euro area relative to the *core inflation* models, and remains highly significant. In Japan, the coefficient on the output gap is not significant.
    - In the core goods models, the output gap coefficients turn negative and are not significant in the United States, but remain positive and significant in the euro area. In Japan, the output gap coefficient is again not significant.[9]
- The fit of the Phillips curves is better for core services inflation than for core goods inflation in both the United States and the euro area.
- The relative price of imports increases the fit of the core goods inflation models for both the United States and the euro area, but not for core services inflation models.
- Oil prices do not improve the fit of the core services and goods Phillips curves in the three regions.
- Inflation expectations appear to be more backward-looking in the euro area than in the United States and Japan, as the smaller size of the coefficient for long-term inflation expectations would suggest in the euro area.
- In the United States, both the *total* and *core* inflation global factors (presented in the previous section) are not significant in any of the estimated US Phillips curves. For the euro area and Japan, the *total* inflation factor is significant in the core goods but not in the core services Phillips curves, while the reverse is true for the *core* inflation factor (i.e., it is not significant in the core goods but it is significant in the core services Phillips curve).

[9] One interpretation of the large negative constant in Chart 11 is the downward pressure on goods prices from globalization during the entire sample period.

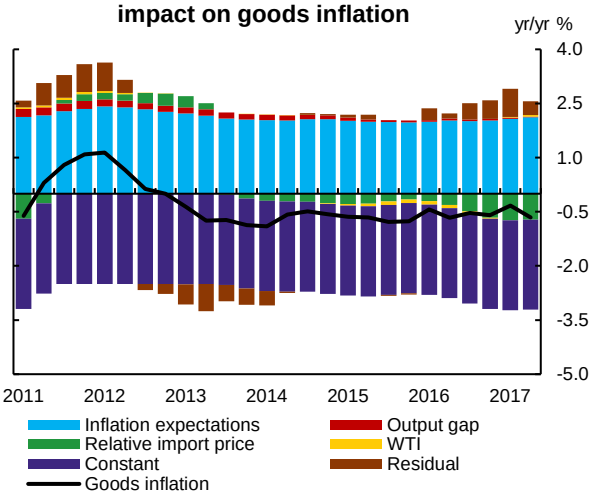
Chart 10: The negative output gap has driven most of the weakness in services inflation



Sources: Survey of Professional Forecasters, Federal Reserve Bank of Philadelphia via Haver Analytics and Bank of Canada calculations

Last observation: 2017Q2

Chart 11: Negative output gap has a negligible impact on goods inflation



Sources: Survey of Professional Forecasters, Federal Reserve Bank of Philadelphia via Haver Analytics and Bank of Canada calculations

Last observation: 2017Q2

5. Conclusions

Underlying core inflation has weakened in several advanced economies since early 2016, raising questions about why inflation is softening at a time when economic conditions suggest it should be picking up. This weakness appears to have subsequently stabilized or partially reversed in the majority of cases, and the more recent decline in US core inflation in 2017 does not appear to be broad-based across advanced economies.

Beyond these very recent dynamics, inflation has been weak in advanced economies for much of the past several years. Most of this weakness in core inflation has been driven by domestic economic slack, and the impact of slack manifests more in service prices than in goods prices. Recent analysis by the Bank as well as the International Monetary Fund show that existing slack in the labour market still plays a key role in keeping wage growth subdued in many advanced economies.[10] As the labour market tightens, wage growth should pick up and support higher inflation.[11]

[10] See Brouillette at al. (2017), IMF (2017).

[11] Recent research also mentions several structural factors for restraining wage inflation such as low productivity growth, demography-induced changes to workforce composition, globalization and digitalization, as well as an increase in monopoly powers and the rise of superstar firms. Bank staff have analyzed the impact of digitalization (through higher productivity, lower cost, e-commerce, etc.) on inflation in a parallel analytical note. The evidence so far suggests that it does not have any quantitatively meaningful role in explaining post-crisis inflation dynamics. Moreover, such structural factors are slow-moving and cannot be an explanation of recent dynamics across advanced economies.

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APPENDIX 1 | Common Global Factors in Advanced Economy Inflation

Table A1: Variance decomposition—share of variation explained by the first common factor

Country	Total Inflation		Core Inflation	
	Full Sample	**Post-2011**	**Full Sample**	**Post-2011**
Australia	0.5	0.42	0.31	0.22
Canada	0.6	0.42	0.24	0.05
Denmark	0.65	0.46	0.32	0.11
Euro Area	0.84	0.54	0.57	0.27
Japan	0.01	0	0.21	0.04
Korea	0.21	0.84	0.28	0.32
New Zealand	0.68	0.67	0.34	0.24
Norway	0.02	0.01	0.02	0.01
Sweden	0.66	0.49	0.12	0.07
United Kingdom	0.32	0.2	0.04	0.02
United States	0.68	0.82	0.18	0.19
Average	**0.47**	**0.44**	**0.24**	**0.14**

Notes: The table lists the share of variation explained by the first common factor for each country using a static factor model. Full sample is defined as 1997Q1–2017Q2; post-2011 period refers to 2012Q1–2017Q2. Cells highlighted in grey are greater than or equal to the average share explained.

APPENDIX 2 | Phillips Curve Estimation Results

The following specification was chosen to estimate the Phillips curves:

$$\pi_t = \theta(y_t - y_t^*) + \lambda\pi_t^e + (1-\lambda)\pi_{t-1} + \beta_0\pi_{t-i}^m + \beta_1\pi_t^{wti} + c$$

In this specification, π_t is core inflation (defined as quarterly inflation, annualized), $(y_t - y_t^*)$ is the output gap, π_t^e is long-term inflation expectations, π_{t-1} is last quarter's inflation rates, π_{t-i}^m is the four-quarter change in import prices relative to domestic prices lagged by i quarters, and π_t^{wti} is the current four-quarter change in the West Texas Intermediate (WTI) oil price.[12]

Table A2: US estimated Phillips curve (in %)

Variable (Lag)	Core PCE	Core Services PCE	Core Goods PCE
Output gap	6.6***	9.1***	-4.9
Long-term inflation expectations[a]	90.3***	66.2***	93.0***
Core inflation (-1)	9.7***	33.8***	7.0***
4-q %Δ Relative import price (-4)	8.6***	4.0*	19.2***
4-q %Δ WTI price	0.3**	0.3	0.2
Constant	-0.5***	0.2	-2.5***
Adjusted R-Squared	**19.3**	**30.6**	**22.8**
Sample	**1995Q1–2017Q2**	**1995Q1–2017Q2**	**1995Q1–2017Q2**

Notes: *p < 0.1, **p < 0.05, ***p < 0.01, Newey-West (1987) heteroskedasticity and autocorrelation consistent standard errors, PCE refers to personal consumption expenditure, WTI refers to West Texas Intermediate.

[a] Long-term inflation expectations as measured by the mean forecast of long-run consumer price index (CPI) inflation reported in the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters

[12] This is similar to the specification estimated in other papers such as Blanchard, Cerutti and Summers (2015), Blanchard (2016) and Yellen (2017).

Table A3: Euro area estimated Phillips curve (in %)

Variable (Lag)	Core CPI	Core Services CPI	Core Goods CPI
Output gap	8.5***	14.8***	11.0***
Long-term inflation expectations[a]	31.4***	43.5***	84.2***
Core inflation (-1)	68.6***	56.5***	15.8***
4-q %Δ Relative import price (-4)	0.5	0.2	2.1**
4-q %Δ WTI price	0	-0.2	-0.2
Constant	0.0*	0.2**	-1.0***
Adjusted R-Squared	**82.7**	**62.8**	**27.2**
Sample	**2000Q1–2017Q2**	**2000Q1–2017Q2**	**2000Q1–2017Q2**

Notes: *p < 0.1, **p < 0.05, ***p < 0.01, Newey-West (1987) heteroskedasticity and autocorrelation consistent standard errors, CPI refers to consumer price index, WTI refers to West Texas Intermediate.

[a] Long-term inflation expectations as measured by the mean forecast of long-run CPI inflation reported in the European Central Bank's Survey of Professional Forecasters

Table A4: Japan estimated Phillips curve (in %)

Variable (Lag)	Core CPI	Core Services CPI	Core Goods CPI
Output gap	9.1*	8.6	25.6
Long-term inflation expectations[a]	76.6***	90.6***	1.64***
Core inflation (-1)	23.4***	9.4***	-0.64***
4-q %Δ Relative import price (-4)	0.6	0.3	-1
4-q %Δ WTI price	-0.3	-0.4	0.1
Constant	-1.1***	-0.9***	-2.9***
Adjusted R-Squared	**62**	**21.2**	**54.6**
Sample	**2000Q1–2017Q2**	**2000Q1–2017Q2**	**2000Q1–2017Q2**

Notes: *p < 0.1, **p < 0.05, ***p < 0.01, Newey-West (1987) heteroskedasticity and autocorrelation consistent standard errors, CPI refers to consumer price index, WTI refers to West Texas Intermediate.

[a] Long-term inflation expectations as measured by the mean forecast of long-run CPI inflation reported in the Consensus Economics forecasts