CHAPTER 3

GLOBAL DISINFLATION IN AN ERA OF CONSTRAINED MONETARY POLICY

Inflation has declined markedly in many economies over the past few years. This chapter finds that disinflation is broad based across countries, measures, and sectors—albeit larger for tradable goods than for services. The main drivers of recent disinflation are persistent economic slack and softening commodity prices. Most of the available measures of medium-term inflation expectations have not declined substantially so far. However, the sensitivity of expectations to inflation surprises—an indicator of the degree of anchoring of inflation expectations—has increased in countries where policy rates have approached their effective lower bounds. While the magnitude of this change in sensitivity is modest, it does suggest that the perceived ability of monetary policy to combat persistent disinflation may be diminishing in these economies.

Inflation rates in many economies have steadily declined toward historically low levels in recent years (Figure 3.1). By 2015, inflation rates in more than 85 percent of a broad sample of more than 120 economies were below long-term expectations, and about 20 percent were in deflation—that is, facing a fall in the aggregate price level for goods and services (Figure 3.2). While the recent decline in inflation coincided with a sharp drop in oil and other commodity prices, core inflation—which excludes the more volatile categories of food and energy prices—has remained below central bank targets for several consecutive years in most of the major advanced economies.

Disinflation can have multiple explanations and is not necessarily a cause for concern. For instance, a temporary decline in inflation due to a supply-driven decline in energy prices can be beneficial to the overall economy. Even when low demand is behind a temporary disinflation, its negative implications may not necessarily go beyond those of depressed demand itself. However, if persistently low inflation leads firms and households to revise down their beliefs about the future path of inflation, it can have negative implications. In particular, if medium-term inflation expectations drift down significantly, a deflationary cycle may emerge in which weak demand and deflation reinforce each other. Eventually, the economy may end up in a deflation trap—a state of persistent deflation that prevents the real interest rate from decreasing to the level consistent with full employment. Moreover, even if deflation is avoided, a persistent downward shift in inflation to very low levels would not be desirable: lower nominal interest rates would leave little room to ease monetary policy if needed, the economy would still not be far from slipping into deflation and, given stickiness in wages, a weakening in demand would be more likely to cause large job losses.

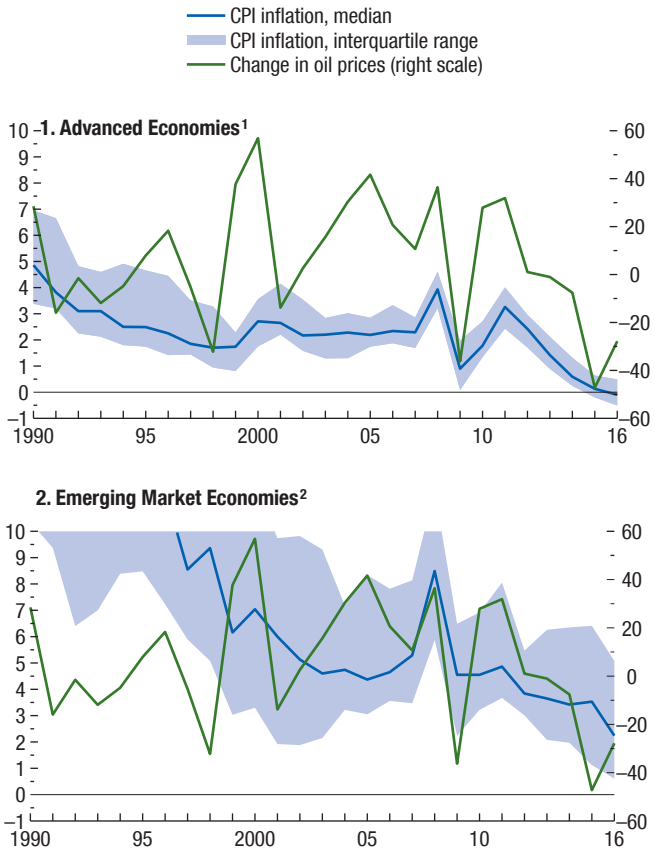
The risk of disinflation potentially leading to a deflation trap or to persistently weak inflation is closely related to whether monetary policy is perceived to be effective in ensuring that inflation converges to its objective once temporary effects fade. At the current juncture, the ability of central banks to keep inflation expectations anchored could be challenged by several factors. First, the scope of monetary policy to further stimulate demand is perceived to be increasingly constrained in many advanced economies where policy rates are not far from their effective lower bounds. Second, in many countries, the weakness in inflation to some extent reflects price developments abroad—in particular substantial slack in tradable goods–producing sectors in several large economies.[1] Although domestic monetary policy can do little to combat deflation pressure from abroad, its credibility may end up undermined if weakness in import prices combines with weak demand at home to keep inflation

The authors of this chapter are Samya Beidas-Strom, Sangyup Choi, Davide Furceri (lead author), Bertrand Gruss, Sinem Kılıç Çelik, Zsoka Koczan, Ksenia Koloskova, and Weicheng Lian, with contributions from Jaebin Ahn, Elif Arbatli, Luis Catão, Juan Angel Garcia Morales, Keiko Honjo, Benjamin Hunt, Douglas Laxton, Niklas Westelius, and Fan Zhang, and support from Hao Jiang and Olivia Ma. Refet Gürkaynak was the external consultant for the chapter. Comments from Jesper Linde and Signe Krogstrup are gratefully acknowledged.

[1]Investment in tradable goods sectors in some large economies, notably China, grew strongly in the aftermath of the global financial crisis, in part because of a sizable macroeconomic policy stimulus. The increase in investment was underpinned by a path of projected global and domestic demand that subsequently fell short of expectations, leaving several manufacturing sectors with substantial overcapacity (see IMF 2016b).

Figure 3.1. Oil Prices and Consumer Price Inflation
(Percent)

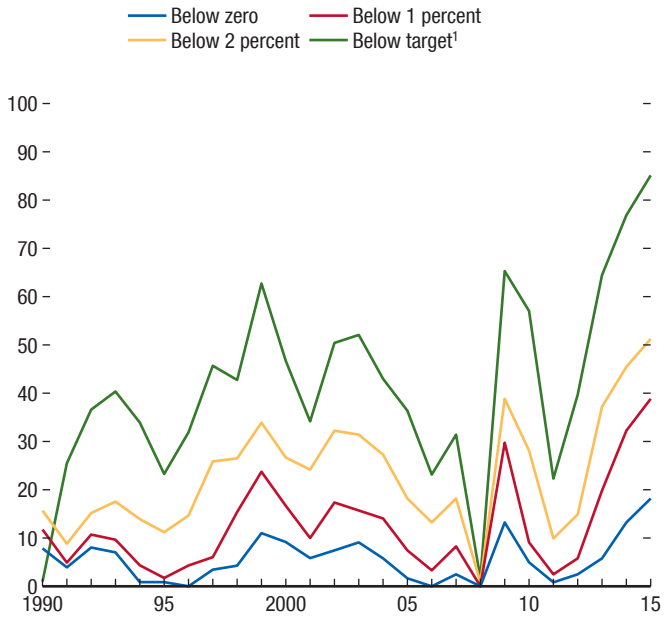
Inflation has steadily declined toward historically low levels in recent years, both in advanced and emerging market economies.



Sources: Haver Analytics; and IMF staff calculations.
Note: CPI = consumer price index.
[1] Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.
[2] Argentina, Brazil, Bulgaria, Chile, China, Colombia, Dominican Republic, Ecuador, Egypt, Hungary, India, Indonesia, Jordan, Kazakhstan, Malaysia, Mexico, Morocco, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Venezuela.

Figure 3.2. Share of Countries with Low Inflation
(Percent)

A large number of countries are currently facing low inflation or even deflation.



Sources: Consensus Economics; and IMF staff calculations.
Note: The figure is based on an unbalanced sample of 120 countries.
[1] Target refers to long-term inflation expectations from Consensus Economics (10-year inflation expectations) or inflation forecasts from the World Economic Outlook database (5-year inflation expectations).

rates persistently below target. After a long period of stability, certain measures of medium-term inflation expectations have indeed fallen in some advanced economies—especially after the decline in oil prices in 2014 (Figure 3.3).[2] Against this backdrop, there is a growing concern that further disinflationary shocks could keep inflation persistently low and eventually lead to deflation trap conditions.

To assess these risks and contribute to the policy debate, this chapter investigates the following questions:

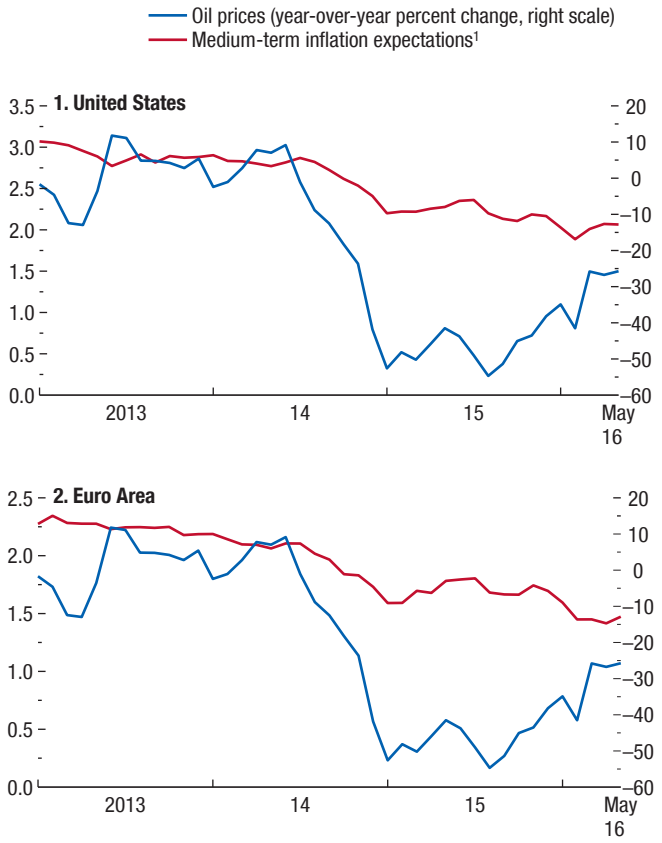
- How widespread is the recent decline in inflation across countries? Does the extent of the decline vary by type of measure—headline, core, wages—and by sector?
- Can the weakening in commodity prices and economic slack explain recent inflation dynamics? What is the role of other factors, including cross-border spillovers from industrial slack in large economies?[3]

[2]As measured by inflation compensation embedded in long-maturity nominal bonds or swaps.

[3]Industrial slack in light and heavy industries (including commodities)—generated either by weak demand or an excess of supply stemming from previous overinvestment—results in lower producer prices and, in the case of traded goods, lower export prices. Several studies point to marked overcapacity in a range of industrial sectors (National Association of Manufacturers 2016; Organisation for Economic Co-operation and Development 2015). Estimates presented in Box 3.1 suggest that industrial slack in the first quarter of 2016

Figure 3.3. Medium-Term Inflation Expectations and Oil Prices
(Percent, unless noted otherwise)

Medium-term inflation expectations have fallen over the recent past, especially since the sharp drop in oil prices in 2014.



Sources: Bloomberg L.P.; and IMF staff calculations.
[1] Medium-term inflation expectations are based on five-year/five-year inflation swaps.

- Have inflation expectations become more sensitive to inflation outturns in recent years, especially in countries where monetary policy is perceived as being constrained? How large is the risk that a decline in inflation will lead to lower inflation expectations? How do monetary policy frameworks affect the degree of anchoring of inflation expectations?

The chapter starts by discussing the potential costs of persistently low inflation and deflation. Next, it examines the evolution of inflation across countries and the factors driving it during the past decade. It then explores the sensitivity of inflation expectations to changes in inflation and the role of monetary policy frameworks in affecting this sensitivity.

The key findings of the chapter suggest that persistently below-target inflation poses downside risks and calls for a number of policy responses. Specifically,

- Disinflation is a broad-based phenomenon. Inflation has declined across many countries and regions, in both headline and core measures, but more markedly in tradable goods sectors than in services.
- Economic slack and changes in commodity prices are the main drivers of lower inflation since the Great Recession. In addition, industrial slack in large exporters (such as Japan, the United States, and especially China) may also have contributed to lower inflation by putting downward pressure on global prices of tradable goods (Box 3.1).[4] However, the recent decline in inflation goes beyond what these factors can explain—suggesting that inflation expectations may have dropped more than implied by available measures or that economic slack is greater than estimated in some countries.
- The response of inflation expectations to inflation surprises has been decreasing over the past couple of decades in both advanced and emerging market economies, partly as a result of improvements in monetary policy frameworks. The sensitivity remains larger among the latter, suggesting further scope for improvements in emerging market economies.
- However, in countries where monetary policy is constrained, inflation expectations have recently become more responsive to oil price changes or unexpected movements in inflation itself.

Many advanced economies with low inflation and persistent economic slack run the risk of chronically undershooting their inflation targets, which would erode the credibility of monetary policy. To avoid this risk, policymakers in these economies need to boost demand and firm up expectations. With limited policy space, a comprehensive and coordinated approach that exploits the complementarities among all available tools to boost demand and that amplifies the effects of individual policy actions through

stood at about 5.5 percent in China, 5 percent in Japan, and 3 percent in the United States.

[4]Industrial production in China, Japan, and the United States accounts for a significant share of total world industrial production (about 45 percent), which is even larger than the share of these economies in global GDP (about 38 percent).

positive cross-border spillovers would be the most effective (Gaspar, Obstfeld, and Sahay forthcoming). This approach should be centered on continued monetary policy accommodation to help keep medium-term inflation expectations anchored—including a transparent commitment to more aggressive accommodation where there are signs that expectations are becoming unanchored.[5] But monetary stimulus should be complemented with a combination of a more growth-friendly composition of fiscal policy, an expansionary fiscal stance in countries with credible medium-term fiscal frameworks and available fiscal space, and structural reforms that stimulate consumption and investment through higher expected incomes and profits. Income policies could be used in countries where wages are stagnant and deflation expectations appear entrenched (IMF 2016a). Distortionary policies that perpetuate overcapacity should be avoided as they not only worsen resource allocation—and weaken asset quality in the banking system where financed by credit—but also exert disinflationary pressures on other economies.

Although low inflation is a less pervasive phenomenon among emerging market economies, improving monetary policy frameworks is also a policy priority in many of these countries. Additional efforts to strengthen the credibility, independence, and effectiveness of central banks would improve the degree of anchoring of inflation expectations, enhancing the ability to fight deflationary forces in some cases and above-target inflation in others.

A Primer on the Costs of Disinflation, Persistently Low Inflation, and Deflation

Like high inflation, persistently low inflation, disinflation, and deflation can potentially have a severe impact on an economy. Whether they entail costs, and how large these costs are, depends on their underlying sources, their extent and duration, and, most importantly, the degree of anchoring of inflation expectations.

Unexpected Disinflation

An unexpected decline in the inflation rate can harm demand in an economy with high debt by increasing the real debt burden of borrowers and the real interest rate they face—a phenomenon called "debt deflation"—and increase difficulties in achieving deleveraging (see the October 2016 *Fiscal Monitor*). The increase in the real burden of servicing debt would be more severe under outright deflation. While creditors' wealth rises with debt deflation, they are unlikely to increase their spending enough to offset the macroeconomic consequences of debtors' losses, meaning that debt deflation has a net negative effect on the economy (Fisher 1933). The reduction in collateral values—including house prices—that tends to accompany deflation can result in lower or negative equity, magnifying the problem through costly defaults. Debt deflation not only affects mortgage holders, firms, and banks, but also governments that hold long-maturity debt.[6]

Persistent Disinflation and the Deflation Trap

Persistently low inflation increases the possibility that an adverse shock will reduce the aggregate price level and tip the economy into a deflation trap. But falling into this trap is far from automatic. Inflation expectations would need to drop significantly for this to happen.

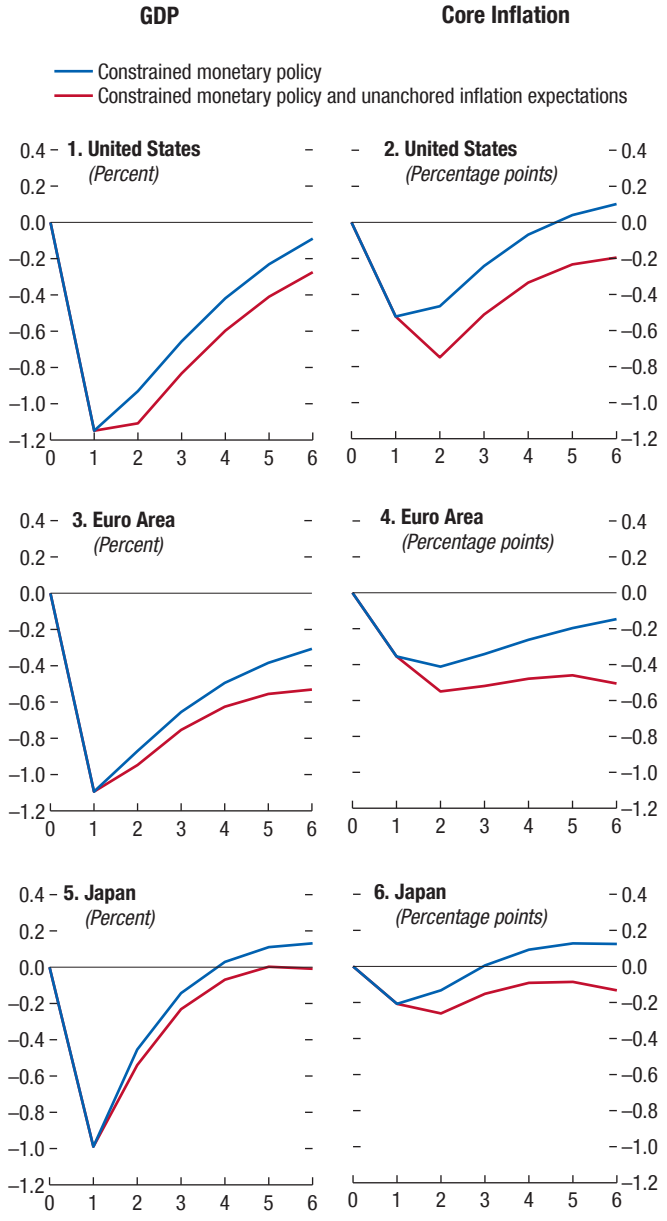
In periods of low inflation, even small disinflationary shocks can lead to a fall in the level of prices of goods and services. If economic agents expect prices to continue to fall, they can become less willing to spend—particularly on durable goods whose purchases can be postponed—since the ex-ante real interest rate increases and holding cash generates a positive real yield. Consumption and investment would be deferred farther into the future, leading to a contraction in aggregate demand that would in turn exacerbate deflation pressures. A deflation cycle would then emerge, with weak demand and deflation reinforcing each other, and the economy could end up in a deflation trap. In this context, the behavior of prices and output

[5]Several empirical studies have documented that certain unconventional monetary policies adopted in the aftermath of the Great Recession had significant impacts on inflation expectations or asset prices that convey information about these. In particular, a number of recent papers have found significant effects on break-even inflation rates (Guidolin and Neely 2010; Krishnamurthy and Vissing-Jorgensen 2011), survey-based inflation expectations (Hofmann and Zhu 2013), and firms' inflation expectations (Cloyne and others 2016), as well as on interest rates and asset prices (Krishnamurthy and Vissing-Jorgensen 2011; Swanson 2016; Wright 2012; Yu 2016).

[6]The effect on governments is especially important in the current environment because as debt rises, fiscal space is reduced. Persistently weak growth in the GDP deflator, and hence in nominal GDP, worsens the interest-rate-growth differential and contributes to a higher debt burden. See End and others (2015) for further details.

Figure 3.4. Effect of Disinflationary Shocks in Advanced Economies under Constrained Monetary Policy and Unanchored Inflation Expectations
(Years after the shock on x-axis)

Demand-driven deflationary shocks can have particularly large and persistent negative effects if monetary policy is constrained and inflation expectations become unanchored.



Source: IMF staff estimates.
Note: The figure reports the deviation of output and core inflation from their baseline path after a temporary decline in domestic demand. It is assumed that conventional monetary policy in all countries is constrained at the effective lower bound on nominal interest rates. The alternative scenario (red line) also assumes that inflation expectations are affected by inflation shocks in line with the empirical evidence presented in the chapter. See Annex 3.2 for further details.

could become unstable if monetary policy is constrained by the effective lower bound on interest rates (see, for instance, Benhabib, Schmitt-Grohé, and Uribe 2002; Cochrane 2016).[7] These difficulties are aggravated if fiscal policy cannot be readily and efficiently deployed to stimulate demand.

The capacity of monetary authorities to maintain medium-term inflation expectations anchored at the target (that is, persuade agents that inflation will eventually converge to the target once the effect of temporary factors fades out) is critical to mitigate such concerns. Indeed, model simulations in Annex 3.2 illustrate that even with constrained monetary policy, an economy would escape the deflation trap induced by a negative demand shock as long as medium-term inflation expectations were well anchored. But if expectations drifted down, it could take a very long time for the economy to emerge from deflation (Figure 3.4).[8]

Persistently Low Inflation

An environment of subdued but positive inflation could carry significant economic costs even if a deflation trap is avoided. A prolonged period of below-target inflation may lead to a belief that the central bank is willing to accept low inflation for longer, effectively reducing inflation expectations for the medium term to positive but below-target levels.

The main cost of this low-inflation environment is reduced effectiveness of monetary policy. Low inflation constrains the ability of monetary policy to respond to depressed demand. In a severe downturn, real interest

[7]Estimates of the probability of a situation of constrained monetary policy with unstable output and price dynamics vary substantially depending on the shocks considered. Previous studies find this probability to be nonnegligible and as high as 5–10 percent when inflation is around 2 percent and financial shocks similar to those in 2007–08 are considered (Blanco 2015; Chung and others 2012; Coibion, Gorodnichenko, and Wieland 2012; Williams 2014). While the probability associated with an episode of monetary policy at the effective lower bound lasting several years—as in the current juncture—is more difficult to estimate with existing models, it is likely to be larger than previous estimates and associated with greater economic costs.

[8]Many theoretical studies have examined the behavior of the economy in a long-lasting liquidity trap in a context in which prices are slow to move—or sticky—and have proposed distinct solutions to escape from it (Buiter and Panigirzoglous 1999; Cochrane 2016; Eggertsson and Woodford 2003; Svensson 2001; Werning 2012). The solutions range from a combination of devaluation, prolonged monetary policy accommodation, and price level targeting to more aggressive approaches, including negative interest rates or "helicopter money."

rates (the nominal rate minus the expected inflation rate) must decrease significantly to restore full employment and bring output back to its potential. With normal levels of inflation, a central bank can accomplish that by reducing the nominal policy interest rate, but when the economy is experiencing low inflation and nominal interest rates, the central bank would have little room to reduce real interest rates, even if it resorted to unconventional tools.[9]

A low-inflation environment may also lead to higher unemployment in the face of adverse demand shocks. When the demand for goods and services declines, firms seek to reduce costs. In this context, inflation facilitates adjustment because it pushes down real wages—even in the presence of downward nominal wage rigidity. Real wages would be less flexible under lower average inflation. In the context of low inflation, cost reduction by firms is more likely to take the form of job cuts (Akerlof, Dickens, and Perry 1996; Bernanke 2002; Calvo, Coricelli, and Ottonello 2012), because it is typically difficult to lower costs by reducing nominal wages.[10]

In Sum: Slow Growth?

While the above economic costs are difficult to quantify, the Great Depression and the more recent Japanese deflation experience (IMF 2003, Box 3.2) suggest that prolonged weak inflation and, especially, persistent deflation may dampen medium-term growth prospects.

Inflation Dynamics: Patterns and Recent Drivers

How Widespread Is the Decline in Inflation?

The evidence points to a broad-based decline in inflation across countries and regions as well as among different measures of inflation, but more markedly in manufacturing than in services. The breadth of the decline in inflation across countries and the fact that it is stronger in the tradable goods sectors underscore the global nature of disinflationary forces.

Headline Inflation

Inflation was surprisingly stable during the Great Recession (2008–10). Indeed, while previous recessions were usually associated with marked disinflation, inflation proved broadly resilient among advanced economies even as unemployment rates climbed to multidecade highs.[11]

However, since 2011, inflation rates began to decline across many advanced and emerging market economies. Headline inflation—the change in the prices of a broad range of goods and services, including food and energy—recently reached historical lows in many countries (Figure 3.5; Box 3.3).[12] Moreover, many advanced economies—notably in the euro area—experienced outright deflation in 2015, and price declines became more widespread in the first quarter of 2016. In many emerging market economies, headline inflation also declined sharply following the drop in oil prices, despite large currency depreciations in some of these economies—even though in some of these economies inflation actually has recently increased, as evidenced by a relatively wider interquartile range in the past year (Figure 3.5, panels 2, 4, and 6).[13] Some emerging market economies with close links to the euro area or with exchange rates pegged to the euro also experienced some deflation. The evidence of a broad-based decline in headline inflation is supported by principal component analysis (Figure 3.6). The results of this analysis show that the contribution of the first common factor—a proxy for the "global" component—to the variation in headline inflation was broadly similar before and after the Great Recession for an entire sample of about 120 countries. However, the contribution increased substantially (from 47 percent to 60 percent) in advanced economies during 2009–15,

[9]Even if unconventional monetary policies such as quantitative easing are adopted, their effects on long-term interest rates and output are uncertain (Williams 2014).

[10]Bernanke and Bewley (1999) suggest that an important reason for the reluctance of firms to cut nominal wages is their belief that such cuts would harm workers' morale.

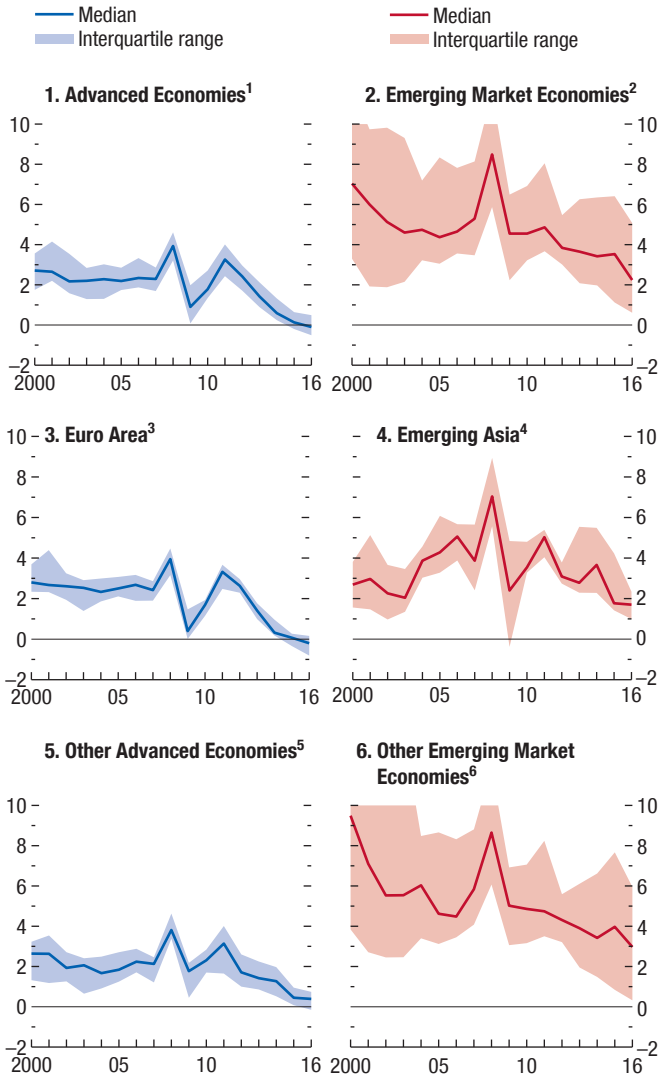
[11]Headline inflation did decline during the crisis, but rebounded quickly. A number of hypotheses were put forward to explain the resilience of inflation, or the missing disinflation—"*the dog that did not bark.*" These include improved credibility of central banks, which helped stabilize inflation outcomes by anchoring inflation expectations (Bernanke 2010); a more muted relationship between cyclical unemployment and inflation—implying a flatter Phillips curve (Chapter 3 of the April 2013 *World Economic Outlook*); and increased wage rigidity that prevented nominal wages from falling as much as during previous recessions. In addition, low inflation contributed to holding up real wages (Daly, Hobijn, and Lucking 2012), and the increase in commodity prices in 2011 may have partly offset the disinflationary impact of increased cyclical unemployment (Coibion and Gorodnichenko 2015).

[12]Box 3.3 explores the role of food price inflation and shows that in some economies, particularly emerging market and developing economies, the global deflation pressure from tradables was mitigated by low pass-through of international food prices to domestic headline inflation.

[13]In emerging market economies, headline inflation has been on a downward trend—in part due to improved monetary policy frameworks. Globalization may have helped reduce inflation in emerging market economies (IMF 2006) by limiting the ability of central banks to temporarily stimulate the economy (Rogoff 2003) and increasing the cost of imprudent macroeconomic policies through the adverse response of international capital flows (Tytell and Wei 2004).

Figure 3.5. Consumer Price Inflation
(Percent)

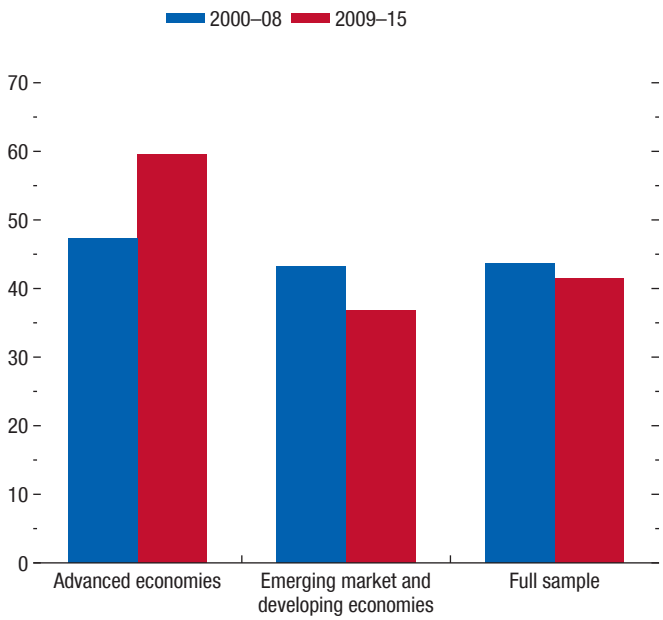
Inflation declined substantially during the global financial crisis in many countries but quickly rebounded afterward. Since 2011, however, there has been a broad-based slowdown in inflation across advanced and emerging market economies.



Sources: Haver Analytics; and IMF staff calculations.
Note: Labels in footnotes 1–6 below use International Organization for Standardization (ISO) country codes.
[1] AUS, AUT, BEL, CAN, CHE, CZE, DEU, DNK, ESP, EST, FIN, FRA, GRC, HKG, ISL, ITA, IRL, ISR, JPN, KOR, LVA, LTU, LUX, NLD, NOR, NZL, PRT, SGP, SVK, SVN, SWE, GBR, USA.
[2] ARG, BGR, BRA, CHN, CHL, COL, DOM, ECU, EGY, HUN, IND, IDN, JOR, KAZ, MAR, MEX, MYS, PER, PHL, POL, ROU, RUS, THA, TUR, VEN, ZAF.
[3] AUT, BEL, DEU, ESP, EST, FIN, FRA, GRE, IRL, ITA, LTU, LUX, LVA, NLD, PRT, SVK, SVN.
[4] CHN, IDN, IND, MYS, PHL, THA.
[5] AUS, CAN, CHE, CZE, DNK, GBR, ISL, ISR, JPN, KOR, NOR, NZL, SGP, SWE, USA.
[6] ARG, BGR, BRA, CHL, COL, DOM, ECU, EGY, HUN, JOR, KAZ, MAR, MEX, PER, POL, ROU, RUS, TUR, VEN, ZAF.

Figure 3.6. Share of Consumer Price Inflation Variation Explained by First Common Factor
(Percent)

The share of consumer price inflation variation across advanced economies that can be attributed to global factors increased during 2009–15.



Source: IMF staff calculations.
Note: The figure reports the share of variation in headline consumer price inflation explained by the first common factor based on a principal component analysis. The sample comprises 120 economies, including 31 advanced economies.

likely reflecting the importance of large movements in commodity prices for headline inflation in largely net commodity importers and the synchronized increase in economic slack since the Great Recession (Annex 3.3).[14]

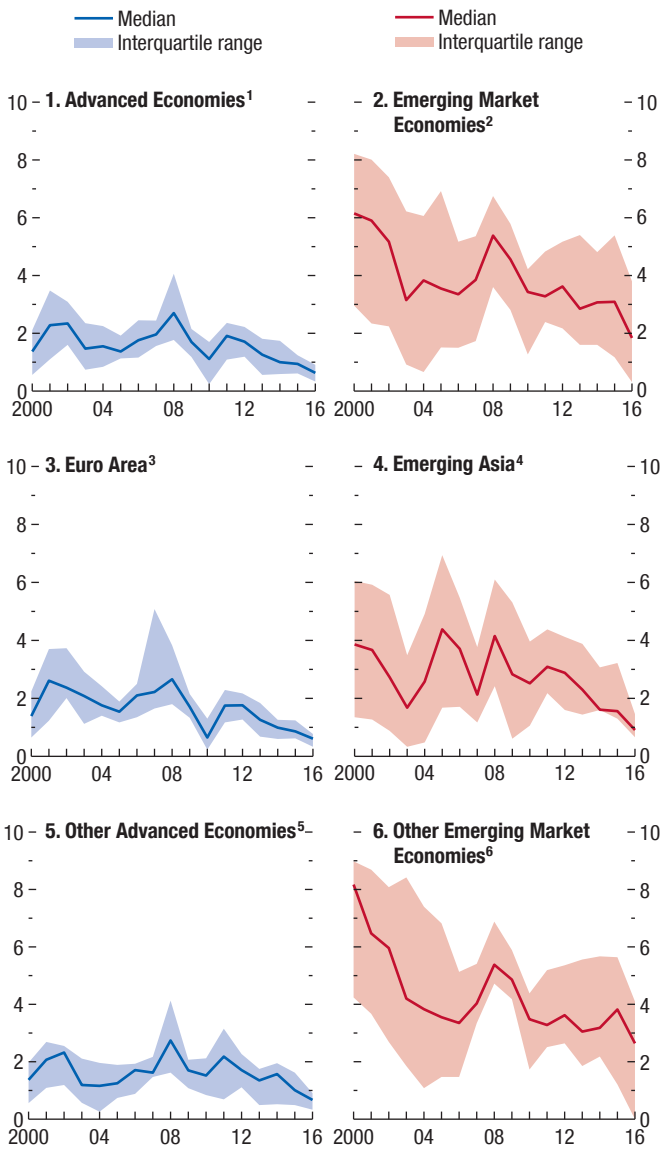
Core Inflation, Wages, and Sectoral Developments

Core inflation—the change in the prices of goods and services excluding food and energy—has also declined widely across countries and regions (Figure 3.7). This measure, which captures the underlying trend in inflation better than headline inflation, has recently been higher than headline inflation given the sharp decline in energy prices. However, core inflation has declined in all advanced economies to rates below central banks' targets and, since 2016, it has also done so in several emerging market economies.

[14]Additional analyses using Bayesian modeling average and weighted least squares confirm that commodity prices stand out among several variables as being strongly linked with the first common factor.

Figure 3.7. Core Consumer Price Inflation
(Percent)

The decline in core inflation over the past few years was broad based across regions.



Sources: Haver Analytics; and IMF staff calculations.
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[2] ARG, BGR, BRA, CHN, CHL, COL, DOM, ECU, EGY, HUN, IND, IDN, JOR, KAZ, MAR, MEX, MYS, PER, PHL, POL, ROU, RUS, THA, TUR, VEN, ZAF.
[3] AUT, BEL, DEU, ESP, EST, FIN, FRA, GRE, IRL, ITA, LTU, LUX, LVA, NLD, PRT, SVK, SVN.
[4] CHN, IDN, IND, MYS, PHL, THA.
[5] AUS, CAN, CHE, CZE, DNK, GBR, ISL, ISR, JPN, KOR, NOR, NZL, SGP, SWE, USA.
[6] ARG, BGR, BRA, CHL, COL, DOM, ECU, EGY, HUN, JOR, KAZ, MAR, MEX, PER, POL, ROU, RUS, TUR, VEN, ZAF.

Wage growth has been increasing recently but remains subdued in many advanced economies despite some improvements in labor markets (Figure 3.8). One reason for the muted behavior, suggested by Daly and Hobijn (2015) for the United States, may be that many firms were unable to reduce wages enough to avoid job cuts during the 2008–09 recession, but as they resumed hiring thereafter, employers were able to keep a lid on wage gains to effectively work off "pent-up wage cuts." The cyclical slack in labor market participation rates may also have kept wages in check during the postrecession recovery.

Sectoral developments in producer prices in advanced economies show that, although inflation has recently softened in all sectors, the decline has been larger in manufacturing producer prices—a typical proxy for the price of tradable goods (Figure 3.9).[15] This may reflect a larger effect of lower commodity prices and lower import prices in manufacturing—given the larger commodity and imported input content in this sector (Box 3.4)—but, for some large advanced and emerging market economies, it is also associated with an increase in excess manufacturing capacity (Box 3.1).

While distinguishing tradable from nontradable components in consumer price indices is challenging, the comparison of inflation across expenditure categories provides supportive evidence that the recent decline in inflation in advanced economies has been substantially stronger in tradable goods (Figure 3.10). On average, the decline in goods inflation has been steeper than in the case of services. Indeed, there has been a widespread decline in the average price level of nonfood goods across advanced economies over the past two years. Instead, food price inflation has slowed but remains generally positive despite the decline in international food prices over the same period—suggesting a rather low pass-through from international to domestic food prices (Box 3.3).

Explaining the Recent Decline in Inflation

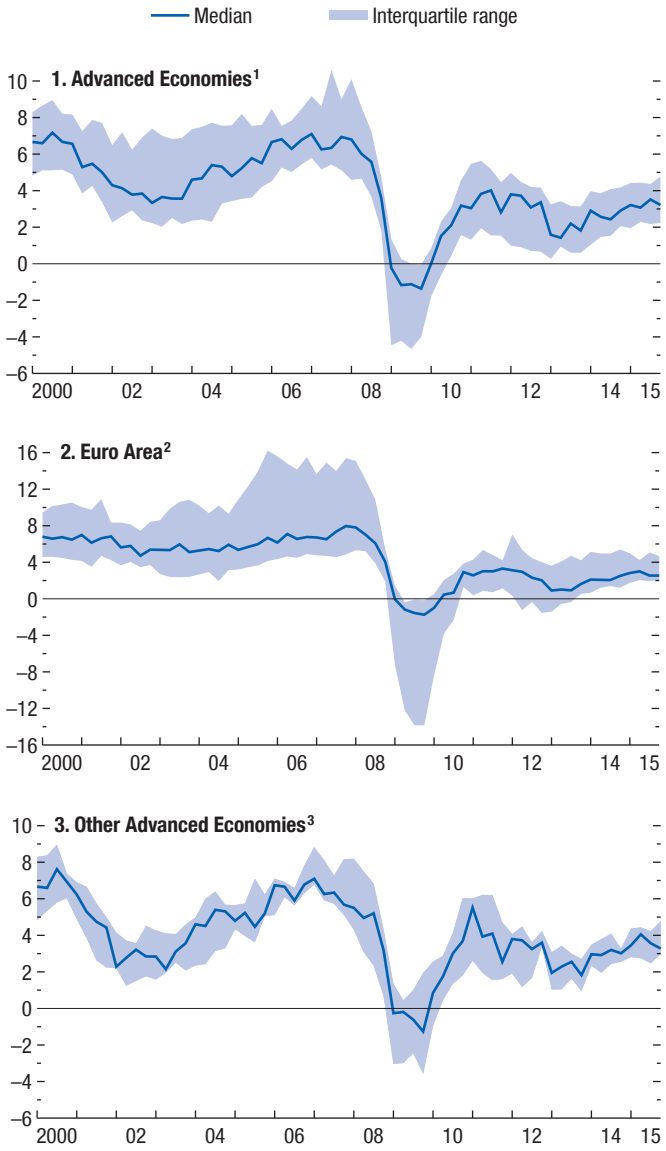
To what extent can declines in oil and other commodity prices and economic slack explain recent inflation patterns? How important is the cross-border transmission

[15]Producer price inflation for manufactured goods has, on average, been lower than total producer price inflation during 1990–2016, while business services inflation has been higher (IMF 2006). Together, manufacturing, business services, and utilities services account for about 70 percent of a typical advanced economy in the sample. The other sectors are agriculture, mining, construction, and social and personal services (including government).

Figure 3.8. Wage Inflation in Advanced Economies

(Year-over-year percent change of nominal wages)

Despite improvements in labor markets, wage growth remains subdued in many advanced economies.

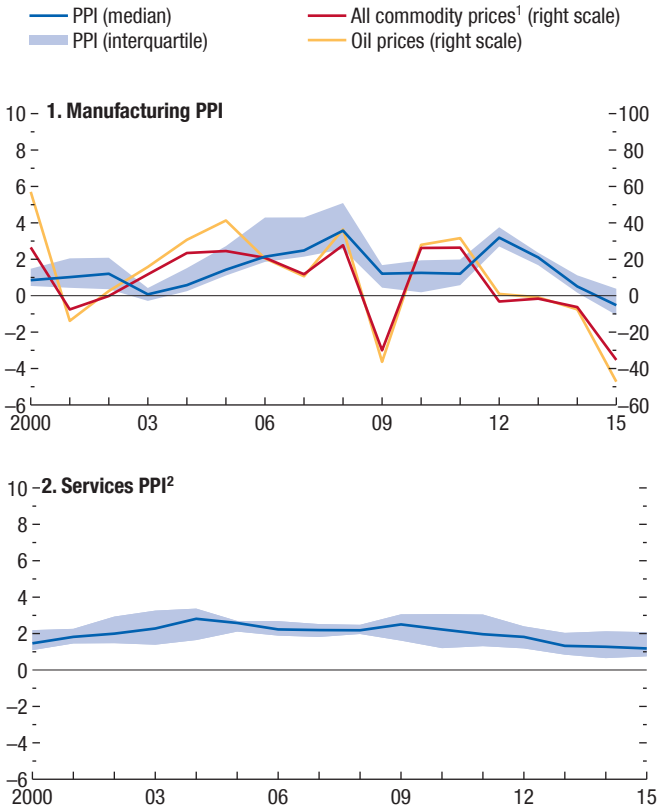


Sources: Organisation for Economic Co-operation and Development; and IMF staff calculations.
[1] Australia, Austria, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Netherlands, Slovenia, Spain, Sweden, United Kingdom, United States.
[2] Austria, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, Netherlands, Slovenia, Spain.
[3] Australia, Canada, Czech Republic, Denmark, Israel, Japan, Sweden, United Kingdom, United States.

Figure 3.9. Sectoral Producer Prices in Advanced Economies

(Percent change)

While producer price inflation in advanced economies has slowed across sectors, the slowdown has been particularly sharp for manufacturing industries.



Sources: Haver Analytics; Organisation for Economic Co-operation and Development, Structural Analysis Database; and IMF staff calculations.
Note: The sample includes Australia, Austria, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Luxembourg, Norway, the United Kingdom, and the United States. PPI = producer price index.
[1] Price index using weights based on 2002–04 average world export earnings.
[2] Services comprise wholesale and retail trade; hotels and restaurants; transportation, storage, and communications; and finance, insurance, real estate, and business services.

of deflation pressure from industrial slack in large economies? How large is the portion of disinflation that cannot be attributed to these factors? To answer these questions, an econometric analysis is performed to assess the contribution of various factors to recent inflation developments.

The empirical framework follows the approach of IMF (2013) and Blanchard, Cerutti, and Summers (2015), building on the hybrid New Keynesian Phillips Curve of Fuhrer (1995) and Galí and Gertler (1999). Specifically, the following version of the Phillips curve is estimated:[16]

$$\pi_t = \gamma_t \pi^e_{t+h} + (1 - \gamma_t)\tilde{\pi}_{t-1} + \theta_t u^c_t + \mu_t \pi^m_t + \varepsilon_t, \qquad (3.1)$$

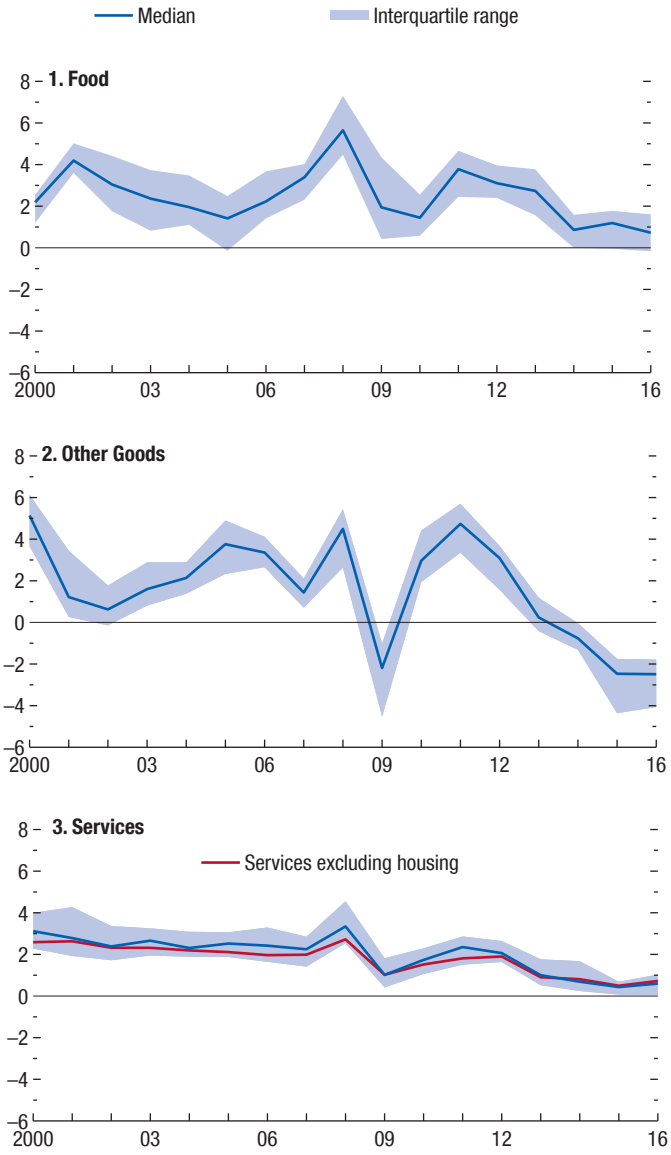
in which π_t is headline consumer price inflation; π^e_{t+h} is inflation expectations h years in the future (with 10-year-ahead expectations used in the baseline specification); $\tilde{\pi}_{t-1}$ is the moving average of inflation over the previous four quarters, to allow for inflation persistence; u^c_t is cyclical unemployment—that is, the deviation of the unemployment rate from its level consistent with stable inflation (the nonaccelerating inflation rate of unemployment, or NAIRU); π^m_t is inflation in the relative price of imports—defined as the import-price deflator relative to the GDP deflator—to account for the impact of import prices, including commodity prices, on domestic consumer prices; and ε_t captures the impact of other factors, such as fluctuations in inflation driven by temporary supply shocks, or measurement error in other variables in the specification—particularly in unobservable variables, such as inflation expectations and cyclical unemployment.[17] The coefficient γ captures the degree to which inflation is driven by long-term inflation expectations as opposed to lagged inflation; θ denotes the strength of the relationship between cyclical unemployment and

[16]There is a vast literature on the ability of alternative Phillips curve specifications to fit the data, particularly for advanced economies (see, for instance, Ball and Mazumder 2011; Fuhrer 1995; Stock and Watson 2007). The specification used here aims for sufficient versatility to accommodate a large sample of heterogeneous economies over a long period.

[17]Some studies use core inflation, producer price inflation, or GDP deflator inflation when estimating a Phillips curve. However, because for many countries measures of expectations are available only for consumer price inflation, which also tends to be the focus of central bank targets, equation (3.1) is estimated for consumer price inflation. The expectation term in the equation should ideally capture the expectations of firms that set prices for consumer goods and services. Since firms' inflation forecasts are not widely available, the analysis uses long-term inflation projections—at a 10-year horizon—from professional forecasters reported by Consensus Economics (Annex 3.4 discusses the choice of forecast horizon and the robustness of results to using different measures).

Figure 3.10. Sectoral Consumer Prices in Advanced Economies
(Percent change)

Consumer price inflation declined more for goods than for services, with deflation for nonfood goods in most advanced economies.



Sources: Haver Analytics; and IMF staff calculations.
Note: "Food" comprises food and beverages. "Other goods" comprises fuels, purchases of vehicles, and all categories under the following expenditure groups: clothing and footwear; electricity, gas, and other fuels; and furnishings, household equipment, and routine maintenance. All other consumer price categories are in "Services." Country sample includes Austria, Belgium, Canada, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

inflation—the slope of the Phillips curve; and μ is the effect of relative import prices on inflation.

The estimation allows for time variation in all the parameters to capture possible changes in the structure of each economy.[18] The model is estimated for each advanced and emerging market economy for which data are available, yielding estimates for a set of 44 countries from the first quarter of 1990 to the first quarter of 2016. The estimates are then used to assess the contribution of labor market slack and import prices to recent inflation dynamics in each country.[19]

Before turning to examine which factors have contributed to the recent decline in inflation, it is useful to assess whether the parameters of the Phillips curve have changed over time. The results suggest that the parameters are broadly stable and, in particular, there is no strong evidence that the slope of the Phillips curve has declined since the mid-1990s (Figure 3.11).[20] A notable exception, particularly for advanced economies, is the degree to which inflation is driven by long-term inflation expectations as opposed to past inflation. The estimated coefficient on expected inflation (γ) steadily increased up to the Great Recession but has been declining since then and now stands at levels comparable to those in the early 1990s (about 0.6).[21] The consequent increase in the coefficient on lagged inflation (1 - γ) implies that inflation has become more backward looking. This implies that the effect of cyclical unemployment and import prices on inflation has become more persistent in the recent period.

Despite some heterogeneity across countries, the results of the country-by-country decompositions show that unemployment slack and weaker import prices are, on average, the most important factors in explaining deviations of inflation from inflation targets in advanced economies since the Great Recession (Figure 3.12). Instead, changes in long-term inflation expectations (as measured by 10-year-ahead expectations by professional forecasters) have played a limited role—although repeating the exercise with expectations at shorter horizons suggests a larger contribution from inflation expectations (see Annex 3.4).

Although parameters are allowed to vary over time—therefore capturing possible nonlinearities (Swamy and Mehta 1975)—the model residuals ("others" in Figure 3.12) have increasingly contributed to the decline in inflation over the past few years. This could reflect a host of factors, including measurement errors in some of the explanatory variables. In particular, expectations of actual price setters may have dropped more than those of professional forecasters (Coibion and Gorodnichenko 2015). Also, underestimation of the extent of unemployment slack could be reflected in larger residuals.[22]

As an aside, the results also suggest that the reason inflation in advanced economies did not fall more between 2008 and 2012 is that the positive effect on inflation of import prices, notably oil prices, partly offset the disinflationary effect stemming from high labor market slack.[23] Accordingly, as import prices started to fall in 2012, inflation began to weaken and undershoot targets.

The decomposition for emerging market economies shows significant heterogeneity. In countries where inflation has recently fallen below long-term inflation expectations, labor market slack, import prices, and, to a lesser extent, currency appreciations explain, on average, the bulk of the recent decline (Figure 3.13, panel 1). In contrast, currency depreciations—notably in commodity exporters—contributed to the increase in inflation in those emerging market economies with inflation currently above long-term expectations. The model residuals over the recent years are particularly large in these economies (Figure 3.13, panel 2), possibly reflecting greater measurement error on inflation expectations as well as changes in administered prices in some cases.[24] Similar to the case of advanced economies, the roles played by these factors vary across countries (Figure 3.13, panels 3 and 4).

[18]For example, improvements in the conduct of monetary policy and structural factors—such as globalization and changes in rigidities in product and labor markets—may have affected the sensitivity of inflation to fluctuations in domestic production (April 2006 *World Economic Outlook*, Chapter 3, and references therein; Rogoff 2003).

[19]The decomposition of inflation dynamics is conducted in a manner similar to that in Yellen (2015). See Annex 3.4 for details.

[20]This finding is in line with that of the April 2013 *World Economic Outlook*, Chapter 3, and Blanchard, Cerutti, and Summers (2015), which document that the flattening of the Phillips curve from the 1960s to the 2000s was largely completed by the mid-1990s.

[21]The finding that the parameter increased during the 1990s is consistent with earlier research, including IMF (2013). That study also finds that the link between current and past inflation started to strengthen since the Great Recession.

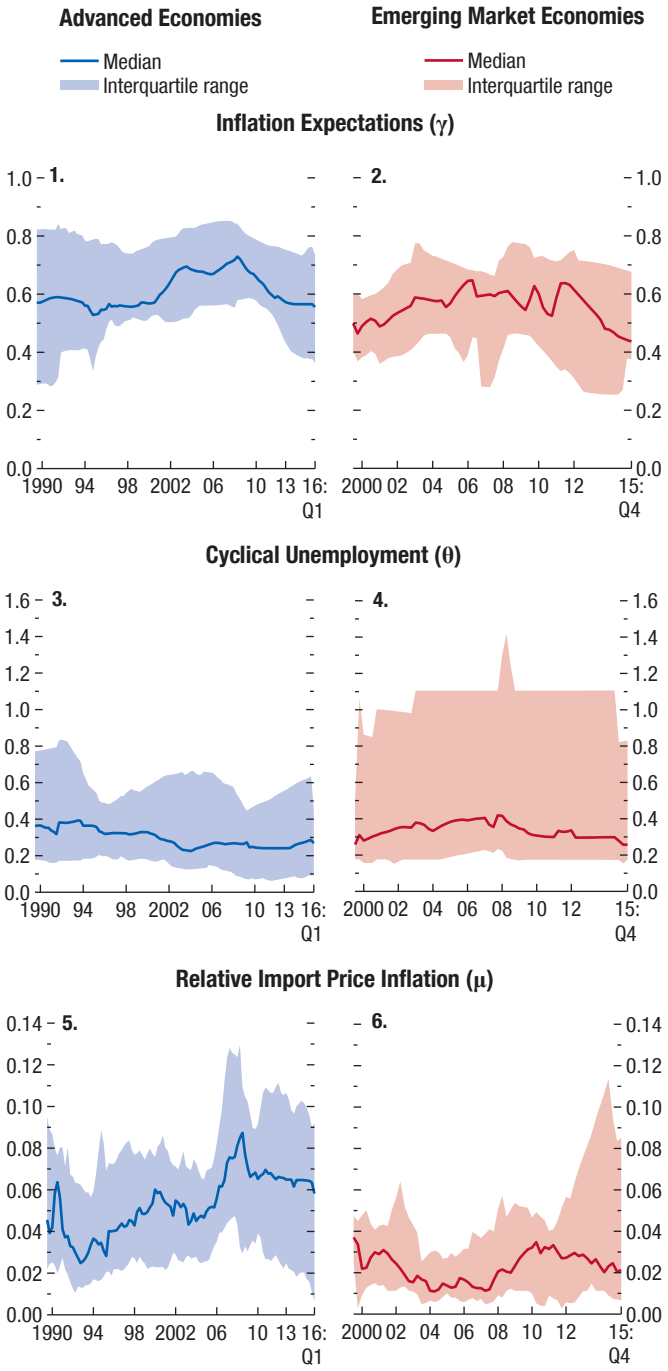
[22]The exercise reported in Annex 3.4 shows that the results are typically robust to using alternative measures of cyclical unemployment but somewhat sensitive to using inflation expectations at different horizons.

[23]Coibion and Gorodnichenko (2015) and Yellen (2015) find similar results for the United States.

[24]Indeed, robustness exercises in Annex 3.4 show that the residuals vary considerably across different measures of inflation expectations and are much smaller when using inflation expectations at shorter horizons.

Figure 3.11. Estimated Phillips Curve Parameters

Estimation results suggest that the degree of anchoring of inflation to long-term expectations increased in the 1990s and early 2000s but declined more recently toward the level attained in the early 1990s. Other parameters, including the slope of the Phillips curve, have been broadly stable.

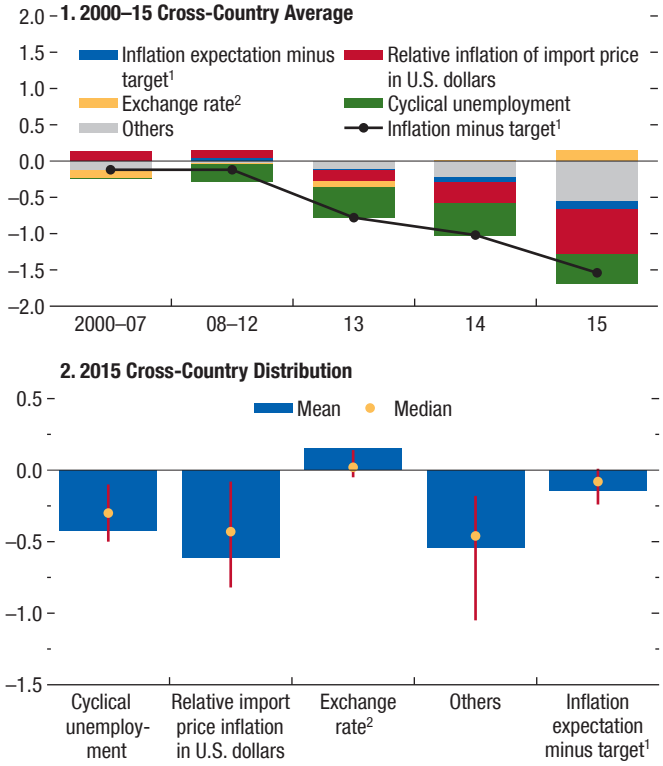


Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: The sample is defined in Annex Table 3.1.1. Venezuela is excluded because of missing data.

Figure 3.12. Contribution to Inflation Deviations from Targets: Advanced Economies

(Percent)

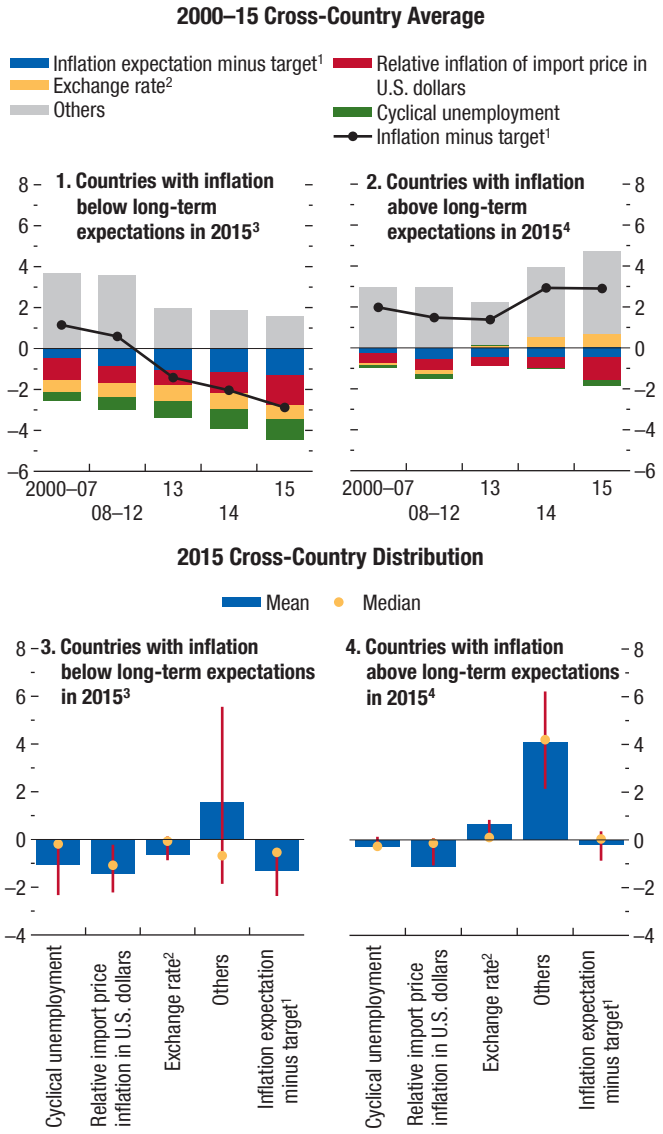
Cyclical unemployment and weaker import prices can account for the bulk of the deviation of inflation from targets in advanced economies since the global financial crisis, but other unexplained factors have been playing an increasingly larger role more recently.



Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Vertical lines in panel 2 denote interquartile ranges. The sample is defined in Annex Table 3.1.1. Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia are excluded as outliers.
[1] Target refers to the average of long-term inflation expectations in 2000–07, which are from Consensus Economics (10-year inflation expectations) or *World Economic Outlook* inflation forecasts (5-year inflation expectations).
[2] Exchange rate is defined as currency value per U.S. dollar.

Figure 3.13. Contribution to Inflation Deviations from Targets: Emerging Market Economies

Economic slack and weak import prices also account for a large share of the observed disinflation in emerging market economies with inflation below long-term inflation expectations over the recent past. In contrast, exchange rate depreciations and other unexplained factors played a key role in emerging market economies in which inflation has been above long-term expectations.



Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Vertical lines in panels 3 and 4 denote interquartile ranges. The sample is defined in Annex Table 3.1.1. Venezuela is excluded because of missing data. Ukraine is excluded as an outlier.
[1] Target refers to the average of long-term inflation expectations in 2000–07, which are from Consensus Economics (10-year inflation expectations) or *World Economic Outlook* inflation forecasts (5-year inflation expectations).
[2] Exchange rate is defined as currency value per U.S. dollar.
[3] Bulgaria, China, Hungary, Malaysia, Mexico, Philippines, Poland, Romania, Thailand.
[4] Argentina, Brazil, Chile, Columbia, India, Indonesia, Peru, Russia, Turkey.

Given the important role played by import prices, the rising slack in tradables sectors in large economies and systemic trading partners (such as China, Japan, and the United States; Box 3.1) raises an interesting question: are spillovers from industrial slack in large economies an important factor in the decline in import prices and inflation?[25] Further analysis provides suggestive evidence that this may be the case. In many advanced and emerging market economies, the contribution of import prices to inflation over time is correlated with manufacturing slack in China, Japan, and the United States. The average correlation with manufacturing slack in all three countries is important, but is particularly strong in the case of China (Figure 3.14, panel 1; Annex Figure 3.4.3).[26,27]

Causal relationships cannot be inferred from this simple exercise, as many factors could drive manufacturing slack in each of these large economies (including weak demand elsewhere) or be associated with it (for instance, lower international oil prices) and could therefore bias the results. Indeed, the conditional correlation between manufacturing slack and the contribution of import prices to inflation is significantly lower when other global variables—such as oil prices and global demand conditions—are also taken into account (Figure 3.14, panel 2; Annex Figures 3.4.3 and 3.4.4). Nonetheless, the correlation with manufacturing slack in China remains significant and economically meaningful: the recent widening in manufacturing slack of about 5 percentage points would be associated, on average, with a decline in inflation in advanced and emerging market economies of about 0.2 percentage point—down from 0.5 percentage point when the estimation does not control for global conditions.[28]

[25] A single country can take the price of its imports as given, but the world as a whole does not have import prices. Changes in import prices depend on the degree of excess supply or excess demand in globally integrated markets for tradable goods and services.

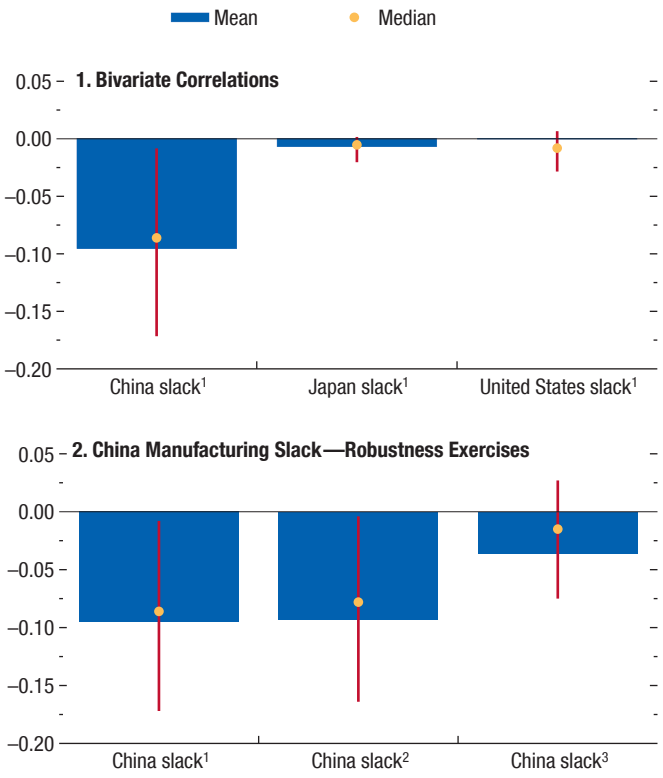
[26] The impact of industrial slack cannot be directly tested in the empirical framework because reliable estimates for it are available only from the mid-2000s (as discussed in Box 3.1). To avoid shortening the Phillips curve estimation period, the analysis instead regresses, country by country, the contribution of import prices on measures of industrial slack in China, Japan, and the United States. See Annex 3.4 for details on the estimation framework as well as robustness checks.

[27] The association between import price contributions and China's manufacturing slack appears to be stronger for advanced economies than emerging market economies (see Annex Figure 3.4.3).

[28] The correlation of the contribution of import prices to inflation and manufacturing slack in China is negative for 84 percent of the sample, and additional results from panel regressions confirm the statistical significance of this result (see Annex 3.4). Further analysis finds that this correlation is higher in countries with stronger trade links with China, providing additional evidence of direct spillover effects through tradable goods. However, slack in China could exert disinflationary pressure on the price of domestic tradable goods

Figure 3.14. Correlation of Manufacturing Slack in China, Japan, and the United States with Import Price Contribution to Inflation in Other Economies
(Percentage points)

Subdued inflation across a large number of countries is associated with manufacturing slack in Japan, the United States, and especially China.



Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Vertical lines denote interquartile ranges. The figure shows the means, medians, and interquartile ranges of coefficients of manufacturing slack from country-specific regressions. See Annex 3.4 for the regression specifications.
[1] No controls.
[2] Controlling for manufacturing slack in the other two economies, change in oil prices, and global output gap.
[3] Controlling for global output gap and change in oil prices in current and previous four quarters.

In sum, while an accounting of the drivers of global manufacturing slack is beyond the scope of this chapter, these findings suggest that manufacturing slack in large economies may add deflation pressure in other economies.

How Well Anchored Are Inflation Expectations?

The previous results suggest that economic slack and the sharp drop in the global price of tradable goods explain a large fraction of the undershooting of inflation targets observed in many countries over the past few years. The contribution of long-term inflation expectations to recent inflation dynamics has been much smaller—although the results are somewhat sensitive to the inflation expectations horizon. But if inflation expectations drift down substantially even as a result of temporary shocks, this would lead to a protracted period of disinflation—especially in the context of constrained monetary policy.[29]

Therefore, a key question in the current juncture is how well anchored inflation expectations are. In particular, is there evidence that recent inflation developments are affecting inflation expectations? To explore that question, the analysis investigates the sensitivity of inflation expectations to changes in actual inflation, examines the role of monetary policy frameworks in influencing this sensitivity, and assesses whether this sensitivity has increased in countries with policy rates at, or close to, their lower bound.

Measuring Inflation Expectations

The link between inflation and economic activity stems in part from the pricing decisions of firms and their beliefs about future macroeconomic outcomes. Because firms' inflation expectations are not generally known, they are approximated by: (1) surveys of inflation expectations of professional forecasters or households and (2) market-based measures of inflation expectations, such as estimates of inflation compensation embedded in the returns of financial instruments.

Survey-based and market-based measures of inflation expectations measure somewhat different concepts and have different statistical properties. Surveys collect one measure of central tendency—the mean, median, or mode—of the believed distribution of individual professional forecasters or households, and different individuals may report a different measure of their believed distribution. It is customary to use the median of this distribution of individual responses as a summary statistic of survey-based expectations to reduce the distortionary

in other countries—when these prices are set in global markets—beyond what is captured through import prices. Indeed, the correlation of model residuals with manufacturing slack in China is statistically significant.

[29]See Annex 3.2 for simulations on the effect of temporarily subdued import prices—stemming from a decline in oil prices and industrial slack in a key large economy—under constrained monetary policy and unanchored inflation expectations.

effect of outliers. The dispersion of expectations in the survey is a measure of heterogeneity of beliefs rather than a measure of uncertainty—although these tend to move together (Gürkaynak and Wolfers 2007). Survey-based measures of professional forecasters' inflation expectations (such as those from *Consensus Economics*) are available at different horizons for a large set of countries while surveys on the expectations of households (such as the University of Michigan survey for the United States) are available only for a few advanced economies.

Market-based measures of inflation expectations can be extracted from inflation compensation embedded in long-maturity inflation-linked and nominal bonds or from inflation-linked swaps.[30] The break-even inflation rate measured by the yield spread between conventional bonds and comparable inflation-linked bonds provides an estimate of the level of expected inflation at which a (risk-neutral) investor would be indifferent between holding either type of bond. It is widely used as a timely measure of investors' inflation expectations, although it is effectively based on the pricing of the marginal investor and includes a liquidity premium and an inflation risk premium.[31]

It is thus not surprising to observe differences in the behavior of survey- and market-based measures over time, including during the most recent period of disinflation. Inflation expectations from professional forecasters for horizons of up to three years vary over time, but expectations for horizons of five years or more are remarkably stable. Households' expectations are also highly stable over longer horizons. In contrast, historical market-based measures of inflation expectations exhibit more variation over time.

Turning to the most recent period, medium-term market-based expectations (five years or more) in the United States and the euro area have fallen by about 0.9 percentage point and 0.8 percentage point, respectively, since 2009—and by about 0.6 percentage point and 0.5 percentage point, respectively, since the sharp drop in oil prices in 2014—and are now significantly below their historical averages and survey-based measures (Figure 3.15, panels 1 and 2). Survey-based inflation expectations have instead declined by much less—about 0.15 percentage point on average since 2009.[32] But, although survey-based medium-term expectations have remained near central banks' targets since the Great Recession, the deviations of inflation expectations from targets in key advanced economies after the crisis have become large even at relatively long horizons such as three years—while under well-anchored inflation expectations these deviations should be zero (Figure 3.15, panels 3 and 4).[33]

Empirical Analysis

The sensitivity of inflation expectations is estimated empirically in a framework that relates changes in inflation expectations to inflation surprises. In particular, the following equation is estimated:

$$\Delta\pi^{e}_{t+h} = \beta^{h}_{t}\pi^{news}_{t} + \epsilon_{t+h}, \tag{3.2}$$

in which $\Delta\pi^{e}_{t+h}$ denotes the first difference in expectations of inflation h years in the future, and π^{news}_{t}

[30]Inflation-linked bonds are now issued in more than 20 countries. In addition to the United Kingdom, the United States, and four large euro area countries, these countries include Brazil, South Africa, Korea, and Turkey. For a historical overview of international inflation-linked bond markets, see Garcia and van Rixtel (2007) and references therein. Inflation-linked swaps are derivatives through which one party pays a fixed rate of inflation in exchange for actual inflation over the length of the contract. The rate of inflation quoted as the fixed leg of the swap can be used to provide an alternative measure of inflation compensation. Inflation-linked swaps are less prone to incorporate a liquidity premium than inflation-linked and nominal bonds because the swaps do not require an upfront payment and are settled by the net exchanges of flows at the end of the contract.

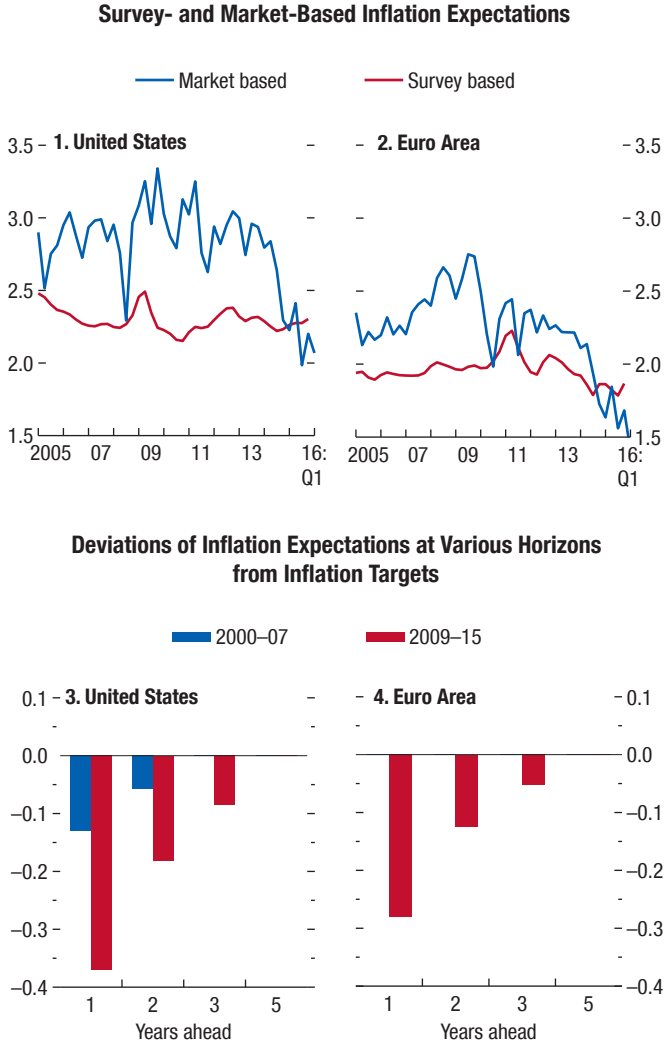
[31]The liquidity premium may arise from factors unrelated to inflation expectations, such as trading frictions or insufficient market activity and could be gauged by looking at relative trade volumes or asset-swap spreads (see, for example, Celasun, Mihet, and Ratnovski 2012; Gürkaynak, Sack, and Wright 2010). The inflation risk premium captures markets' pricing of risk surrounding inflation expectations and is much more difficult to estimate than the liquidity premium. Estimates of the inflation risk premium are typically taken from term-structure models. But, even for a single country, estimates vary significantly over time, across maturities, and across specifications, which makes the interpretation of changes in inflation compensation far from straightforward. For term-structure models applied to the United States, see, for example, Abrahams and others (2012); Christensen, Lopez, and Rudebusch (2010); and D'Amico, Kim, and Wei (2014). For the euro area, see, for example, Garcia and Werner (2014).

[32]Although the expectations of professional forecasters and households have barely declined since the precrisis period, the skew of the distributions has changed. Evidence for the United States suggests that for both of those measures, the share of respondents expecting 1–2 percent inflation has increased, while most of the declines reflect a reduction in expectations for above-target inflation. Inflation expectations based on professional forecasts show a marked reduction in the upper tail, whereas those based on household forecasts point to a reduction in uncertainty.

[33]Empirical evidence for the United States and the euro area suggests that three-year-ahead inflation expectations were not statistically different from inflation targets during the precrisis period but were statistically significantly lower in 2009–15. The analysis controls for the magnitude of inflation shocks in the two periods.

Figure 3.15. Survey- and Market-Based Inflation Expectations
(Percent)

Medium-term market-based inflation expectations have decreased substantially in the United States and the euro area recently. Survey-based inflation expectations fell by much less, but they have deviated significantly from inflation targets even at a three-year horizon.



Sources: Bloomberg L.P.; and IMF staff calculations.
Note: Survey-based inflation expectations in panels 1 and 2 correspond to 5-year-ahead inflation forecasts from Consensus Economics; market-based expectations are based on 5-year/5-year inflation swaps. Panels 3 and 4 show the estimated constant in a regression of deviations of survey-based inflation expectation at different horizons from the inflation target (proxied by 10-year-ahead inflation expectation) on deviations from target of actual annualized quarterly inflation. Estimated coefficients are set to zero if they are not significant at the 5 percent confidence level. Euro area forecasts correspond to the GDP-weighted average of the forecasts for France, Germany, Italy, the Netherlands, and Spain.

is a measure of inflation shocks.[34] The coefficient β^h captures the degree of anchoring in h-years-ahead inflation expectations—a term usually referred to as "shock anchoring" (Ball and Mazumder 2011)—and it is allowed to vary over time in some specifications. If monetary policy is credible, the value of this parameter at a sufficiently long horizon should be close to zero. That is, inflation shocks should not lead to changes in medium-term expectations if agents believe that the central bank is able to counteract any short-term developments to bring inflation back to the target over the medium term. Given uncertainty about the relevant horizon for firms' pricing decisions and in light of the previous results, the exercise is performed using inflation expectations at various horizons.

The model is estimated for each advanced and emerging market economy for which data are available, which produces estimates for 44 countries from the first quarter of 1990 to the first quarter of 2016. The specification allows for the parameter β^h to vary over time to capture changes in the sensitivity of inflation expectations due, for instance, to changes in monetary policy frameworks. The analysis is performed for survey-based inflation expectations using data available at quarterly frequency and for market-based inflation expectations using data available at daily frequency.

Results—Survey-Based Inflation Expectations

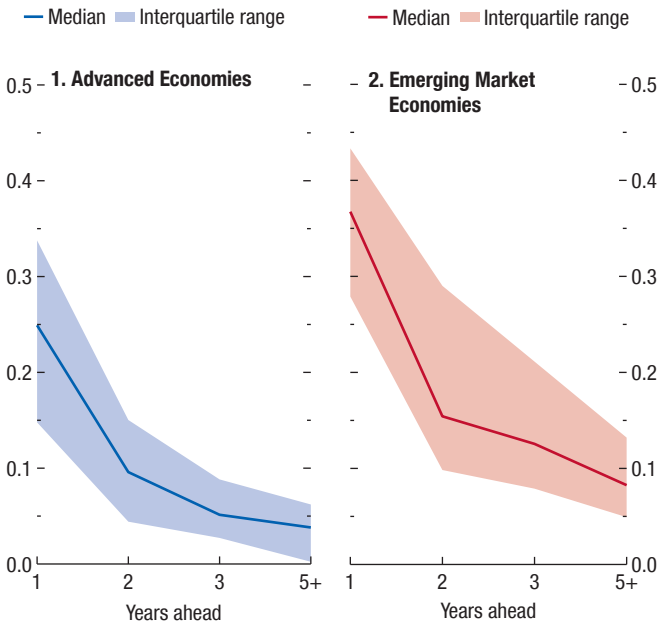
The analysis starts by using a static framework—that is, β^h is assumed constant over time—to explore how the sensitivity of survey-based inflation expectations varies across countries and how this is related to characteristics of monetary policy frameworks.[35] The

[34]Inflation shocks are defined as the quarterly difference between actual inflation and short-term expectations for the analysis based on survey forecast–based measures of inflation expectations and as the daily change in oil price futures for the analysis using market-based expectations. The quarterly forecast error is used as a baseline measure of inflation shocks for the analysis based on survey-based measures of inflation expectations because it is less subject to reverse causality than other measures, such as changes in inflation or deviations of inflation from target. The results using these two alternative measures are, however, not statistically significantly different. Measures of inflation surprises are not available at daily frequency, so changes in oil price futures are used as proxies for inflation shocks for the analysis based on market-based expectations. While the scope of this measure is clearly narrower, inflation expectations have been shown to be strongly related to oil price developments (see Coibion and Gorodnichenko 2015).

[35]This part of the analysis is carried out using a static framework since data for several characteristics of monetary policy frameworks, such as transparency and independence, are available only for a

Figure 3.16. Sensitivity of Inflation Expectations to Inflation Surprises
(Years on x-axis)

Inflation expectations are less sensitive to inflation surprises in advanced economies than in emerging market economies.



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: The figure shows the response of inflation expectations at various horizons to a 1 percentage point unexpected increase in inflation based on coefficients from country-specific static regressions. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations.

estimates show that the sensitivity of inflation expectations is significantly lower in advanced economies than in emerging market economies (Figure 3.16). This is particularly true for inflation expectations at short-term horizons—for example, a 1 percentage point increase in inflation results in a 0.25 percentage point increase in inflation expectations one year ahead for advanced economies, whereas this increase is 0.37 percentage point for emerging market economies. The difference in sensitivity is present, albeit to a lesser degree, even at longer horizons—a 1 percentage point increase in inflation leads to an increase of 0.05 percentage point in three-year-ahead inflation expectations in advanced economies, and of 0.13 percentage point in emerging market economies.

The average lower sensitivity of inflation expectations to inflation shocks in advanced economies points to the credibility of monetary policy frameworks as a possible determinant of the cross-country heterogeneity. An exploration of the differences in estimated sensitivities shows that they are related to measures of central bank independence and transparency—two key areas of central bank governance that have improved dramatically over the past few decades and are positively associated with monetary policy performance (Crowe and Meade 2007).

Medium-term inflation expectations—that is, inflation expectations at three years and at five or more years—are typically better anchored in countries where the central bank is more independent. On average, a 1 unit increase in an index based on the turnover of the central bank's governor—a de facto measure of central bank independence, with higher values associated with a lower degree of independence—is associated with an increase of about 0.3 unit in the sensitivity of inflation expectations (Figure 3.17, panels 1 and 2).[36] This suggests that if a country moves from the 25th percentile to the 75th percentile in terms of turnover—which is similar to the average gap in this independence indicator between the United States and Indonesia in the past 20 years—the sensitivity will increase by 0.03, a nontrivial change considering that the median sensitivity across countries is 0.08.

Analogously, the sensitivity of medium-term inflation expectations to inflation surprises is lower the more transparent the central bank is about its objectives and policy decisions. The results show that, on average, a 1 unit increase in an index of central bank transparency is associated with a 0.16 unit decrease in the sensitivity of three-year-ahead inflation expectations (Figure 3.17, panels 3 and 4).[37] The magnitude

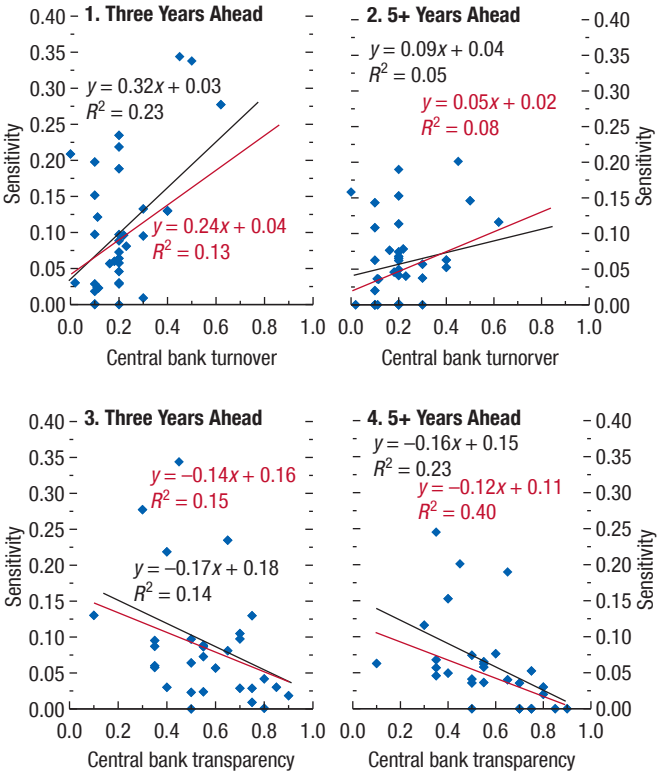
few points in time. The sensitivity of inflation expectations for the survey-based forecast is normalized to measure how much inflation expectations are updated in response to a 1 percentage point change in inflation. See Annex 3.5 for details on the estimation and the computation of inflation shocks.

[36]The central bank governor's term in office shortens relative to that of the executive as turnover increases, making the governor more vulnerable to political interference from the government and reducing the degree of independence of the central bank. Cukierman, Webb, and Neyapti (1992) find that the link between central bank independence and inflation outcomes is stronger when using the de facto measure based on governor turnover than in the case of de jure metrics based on legal measures. Therefore, the analysis uses the governor turnover index from Crowe and Meade (2007), which extended Cukierman, Webb, and Neyapti's (1992) index up to 2004 and includes a large number of emerging market and developing economies.

[37]The central bank transparency index is taken from Crowe and Meade (2007) and corresponds to 1998.

Figure 3.17. Sensitivity of Inflation Expectations to Inflation Surprises and Monetary Policy Frameworks

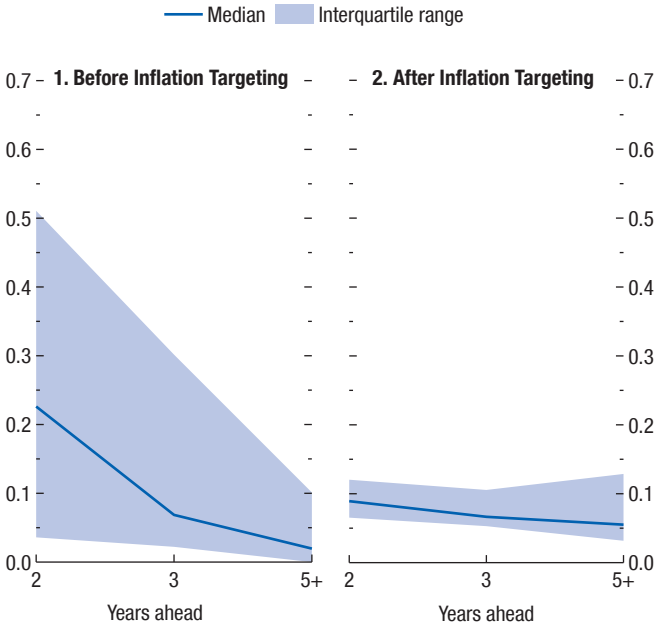
Medium- and long-term inflation expectations are less sensitive to inflation surprises in countries with more independent and transparent central banks.



Sources: Consensus Economics; Crowe and Meade (2007) data set; Haver Analytics; and IMF staff calculations.
Note: The sensitivity is measured as the response of inflation expectations at various horizons to a 1 percentage point unexpected increase in inflation based on coefficients from country-specific static regressions. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations. Black lines denote the fitted lines for the entire sample. Red lines denote the fitted lines excluding outliers.

Figure 3.18. Sensitivity of Inflation Expectations to Inflation Surprises before and after Adoption of Inflation Targeting

Inflation targeting is associated with lower sensitivity of medium- and long-term inflation expectations to inflation surprises.



Sources: Consensus Economics; Haver Analytics; *World Economic Outlook* (2011, Chapter 3); and IMF staff calculations.
Note: The figure shows the response of inflation expectations at various horizons to a 1 percentage point unexpected increase in inflation based on coefficients from country-specific static regressions. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations.

of the estimated coefficient suggests that if a country moves from the 25th percentile to the 75th percentile in terms of transparency—which is similar to the average gap in the transparency indicator between Peru and Canada over the past 20 years—the sensitivity would decline by 0.05.

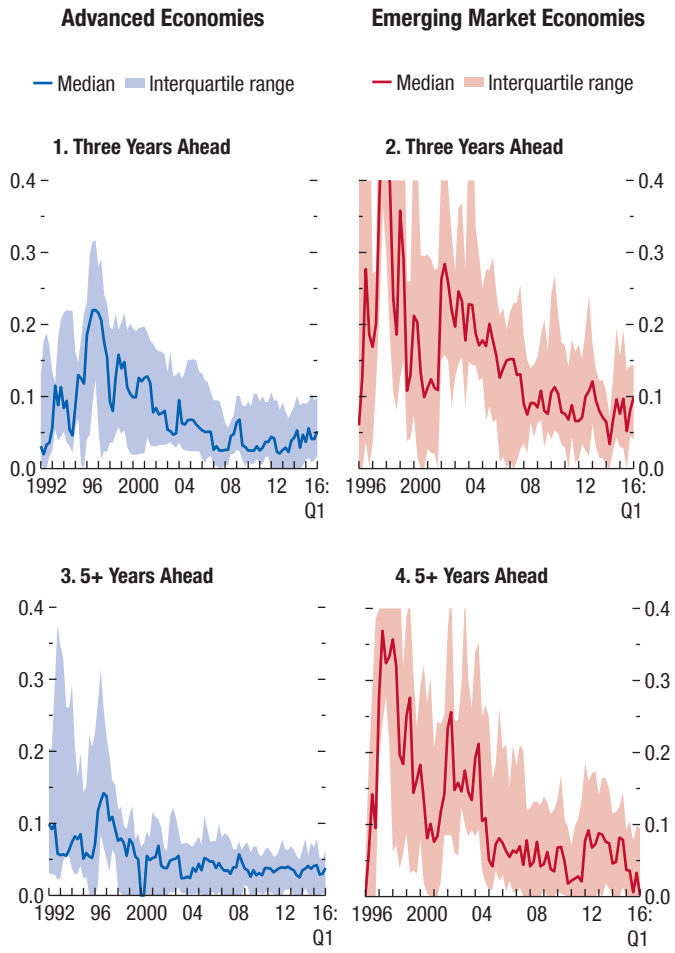
Many central banks have adopted inflation targeting over the past few decades precisely to make their decision-making process more transparent. Comparing the sensitivity of inflation expectations to inflation surprises in each country before and after the adoption of inflation targeting suggests that those monetary reforms are associated with a considerable decrease in sensitivity (Figure 3.18). The drop in sensitivity is observed for all countries in the sample, as evidenced by a relatively narrow interquartile range.[38]

Overall, the results using a static framework suggest that stronger monetary policy frameworks are associated with better-anchored inflation expectations. Allowing the estimate of the sensitivity of inflation expectations (β^b) to vary over time shows that it has declined steadily in both advanced and emerging market economies over the past two decades (Figure 3.19). The decline was steeper at the beginning of the sample period, precisely when many economies significantly improved their frameworks, including

[38]See Levin, Natalucci, and Piger (2004) for a similar finding. Clarida and Waldman (2008) find that higher-than-expected inflation leads to an appreciation of the nominal exchange rate in countries with inflation targeting regimes—but not in others—suggesting that inflation targeters are successful in anchoring expectations of inflation and the monetary path required to meet the target.

Figure 3.19. Sensitivity of Inflation Expectations to Inflation Surprises over Time

The sensitivity of inflation expectations to inflation surprises has been steadily declining over time. But this downward trend seems to have come to a halt more recently, especially among advanced economies.



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: The figure shows the response of inflation expectations at various horizons to a 1 percentage point unexpected increase in inflation based on time-varying coefficients from country-specific estimations using a Kalman filter. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations.

by adopting inflation targeting regimes.[39] It has also been broad based across countries, as illustrated by the evolution of the interquartile range. The observation that the sensitivity of inflation expectations to inflation surprises remains lower in advanced economies than among emerging market economies suggests there is scope for further improvements in the monetary policy frameworks in the latter group.

However, the downward trend in the sensitivity of expectations seems to have come to a halt in the mid-2000s, especially among advanced economies. In addition, the sensitivity of medium-term inflation expectations over the recent past has been increasing steadily faster in countries with policy rates at, or close to, their lower bound than in other countries (Figure 3.20).[40] This has happened even though many of these economies adopted unconventional monetary policies during this period, suggesting that constrained monetary policy may be affecting the degree of anchoring of inflation expectations.

An analysis of the response of inflation expectations to positive and negative inflation shocks also points to constrained monetary policy as the underlying cause of a possible unanchoring of expectations. If constraints on monetary policy are the source of the increased sensitivity of inflation expectations, this sensitivity should be higher for negative shocks than for positive ones—a central bank constrained by the effective lower bound on policy rates can always respond to higher inflation by raising the policy interest rate, but has little scope to reduce it when inflation is declining. This creates an unavoidable asymmetry in the ability of the monetary authority to handle downward and upward inflation shocks.

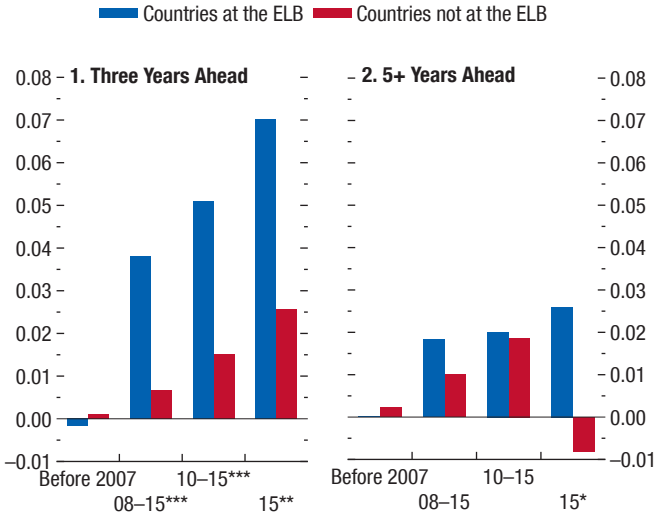
Indeed, most of the increased sensitivity for countries with constrained monetary policy seems to stem from negative inflation shocks (Figure 3.21). After 2009, when policy rates approached their effective lower bounds, the response of medium-term inflation expectations to negative shocks exceeded the response to positive shocks, while the response to positive shocks was larger

[39]For example, in 1996 only about 20 percent of countries in the sample had an inflation-targeting regime; by 2015 the proportion had increased to about 75 percent. Similarly, the sample average of the transparency indicator increased from 0.55 in 1998 to 0.61 in 2006, and the turnover indicator decreased from 0.29 in 1980–89 to 0.20 in 1995–2004.

[40]In this analysis, the effective-lower-bound constraint refers to the policy rate being equal to or less than 50 basis points. The monetary authorities of the following 19 advanced economies faced this constraint at some point during 2009–15: Canada, the Czech Republic, Estonia, France, Germany, Hong Kong SAR, Italy, Japan, Latvia, Lithuania, the Netherlands, Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Singapore does not use an interest rate as a monetary policy instrument, but the level of short-term market interest rates is at the effective lower bound. The statistical significance of the difference is tested using Mood's median test. The difference between the two groups is statistically significant for expectations at a three-year horizon and, to a lesser extent, for inflation expectations at a five-year horizon.

Figure 3.20. Change in Sensitivity of Inflation Expectations to Inflation Surprises

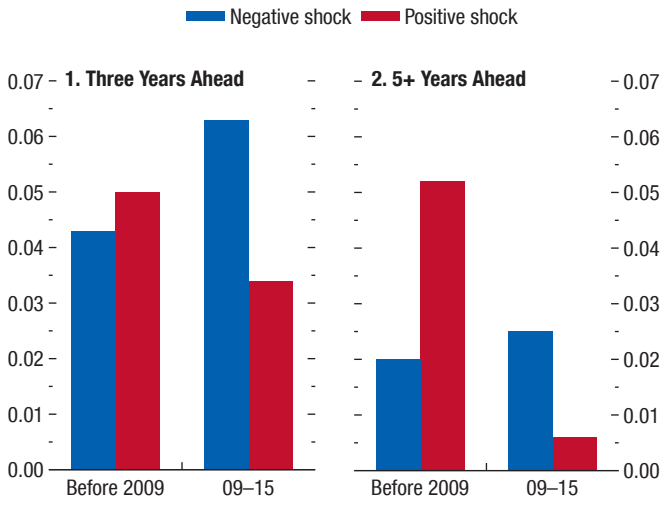
The sensitivity of medium-term inflation expectations to inflation surprises is higher in countries whose monetary policy is constrained.



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: ELB = effective lower bound. ***,**,* denote that the differences in the change in sensitivity of inflation expectations between countries at the ELB and the rest are significant at the 1, 5, and 10 percent confidence level, respectively, using Mood's median test. The sensitivity of inflation expectations corresponds to the response of inflation expectations to a 1 percentage point unexpected increase in inflation based on time-varying coefficients from country-specific estimations using a Kalman filter. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations. The change in sensitivity is constructed as the average deviation of the median sensitivity across countries from a linear trend (an exponential trend) fitted over the period 1997–2007 for countries at the ELB (not at the ELB). Countries at the ELB are defined as those with policy rates or short-term nominal interest rates of 50 basis points or lower at some point during 2008–15 and include: Canada, the Czech Republic, Estonia, France, Germany, Hong Kong SAR, Italy, Japan, Latvia, Lithuania, the Netherlands, Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Figure 3.21. Average Sensitivity of Inflation Expectations to Inflation Surprises in Countries at the Effective Lower Bound

In countries whose monetary policy is constrained, medium-term inflation expectations are more sensitive to negative than to positive inflation surprises.



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: The figure shows the response of inflation expectations at various horizons to a 1 percentage point unexpected positive or negative change in inflation based on coefficients from country-specific time-varying estimation. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations. Countries at the Effective Lower Bound (ELB) are defined as those with policy rates or short-term nominal interest rates of 50 basis points or lower at some point during 2008–15 and include: Canada, the Czech Republic, Estonia, France, Germany, Hong Kong SAR, Italy, Japan, Latvia, Lithuania, the Netherlands, Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Japan is excluded from the analysis, because it reached the ELB much earlier than 2009.

before 2009.[41] The estimates imply that if countries with policy rates currently at the effective lower bound faced inflation surprises comparable to those observed over the past two years, long-term inflation expectations would on average drift further down by about 0.15 percentage point. This is not particularly large in absolute terms but still three times larger than if their sensitivity had remained unchanged—while under well-anchored expectations, there should be no impact at all.

The sharp drop in oil prices played an important role in global inflation dynamics over the past few years, and potentially also in the increase in the sensitivity of medium-term inflation expectations to inflation surprises. However, an additional exercise decomposing inflation surprises into oil and non-oil price movements suggests that the latter also contributed to the increase in expectations sensitivity. This result implies that positive inflation shocks stemming from a faster-than-expected recovery in oil prices would only lead to a partial rebound in inflation expectations if economic slack remains significant.[42]

[41]The difference between the sensitivity for positive and negative shocks is generally not statistically significant, probably due to the limited number of observations (Annex 3.5).

[42]For countries with policy rates at their effective lower bound, the sensitivity of inflation expectations to shocks is decomposed between those driven by changes in oil price inflation and those driven by news on core inflation—proxied by the residuals in the regression of inflation shocks on the oil price (see Annex 3.5). The results suggest that, since 2009, the sensitivities of inflation expectations to oil price shocks and core inflation shocks are comparable.

Taken together, this set of results suggests that it is not just the characteristics of recent inflation outcomes—such as the large negative inflation surprises related to the drop in oil prices—that have led to some unanchoring of medium-term inflation expectations. It is rather the combination of such persistent negative inflation surprises and the perception that monetary policy is constrained and may be less effective in bringing inflation back to the central banks' targets that is behind this apparent unanchoring of medium-term inflation expectations.[43]

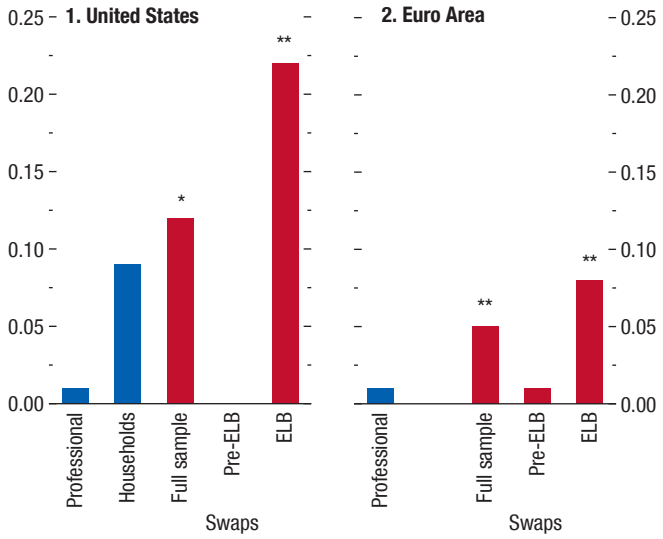
Results—Market-Based Inflation Expectations

The analysis so far provides evidence that: (1) the sensitivity of inflation expectations to inflation surprises depends on monetary policy frameworks and (2) this sensitivity has increased during the most recent period in countries with policy rates close to their effective lower bound, particularly in the case of negative inflation surprises. An analysis using high-frequency data for the United States and the euro area further underscores the relevance of constraints to monetary policy for the unanchoring of inflation expectations. Long-term market-based inflation expectations (approximated by five-year/five-year inflation swaps) are affected by inflation surprises proxied by changes in oil price futures (Figure 3.22). The responses are statistically significant—albeit economically small—both in the United States and in the euro area.[44] Splitting the sample around the time monetary policy rates reached their effective lower bounds shows that the sensitivity of inflation expectations was actually indistinguishable from zero before reaching the lower bound on interest rates, but increased substantially thereafter. The higher elasticities imply that surprises in oil prices can account for about one-third of the decline in market-based inflation expectations since June 2014 in the United States and almost one-fifth in the euro area.[45]

All in all, these empirical findings underscore vulnerabilities at the current juncture, as inflation shocks are predominantly negative and central banks have little space to respond. While the economic significance of the current degree of unanchoring of inflation expectations is still modest, the steady increase in their sensitivity to inflation surprises in cases where monetary policy is constrained is a reason for concern if the undershooting of inflation targets persists.

Figure 3.22. Sensitivity of Longer-Term Inflation Expectations to Changes in Oil Prices

The sensitivity of market-based inflation expectations to inflation surprises in the United States and the euro area increased after policy rates reached their effective lower bounds.



Sources: Bloomberg L.P.; Consensus Economics; University of Michigan Consumer Survey; and IMF staff calculations.
Note: **,* denote significance at the 5 and 10 percent confidence level, respectively. The figure shows coefficient estimates of inflation expectations on changes in oil price futures (simple average of 1-year-ahead Brent and West Texas Intermediate) controlling for changes in the Chicago Board Options Exchange Volatility Index and scaled by a 50 percent drop in oil price futures. Blue bars denote estimation results using survey-based inflation expectations: "Professional" denotes the results using 5-year-ahead inflation forecasts from Consensus Economics; while "Households" denotes results using inflation expectations (5–10 years) from the Michigan survey. Red bars denote results using market-based inflation expectations based on five-year/five-year inflation swaps. The effective lower bound (ELB) is defined as starting in 2009. The full sample refers to the period 2004–16.

[43]An additional estimation was used to explore whether inflation surprises have a larger impact on inflation expectations when they occur after a long period of relatively large and negative inflation outcomes. There is indeed some evidence that, under constrained monetary policy, protracted deviations of inflation from the target can be associated with increased sensitivity of inflation expectations to inflation surprises. However, the results are somewhat sensitive to the sample periods.

[44]The responses of professional and household survey-based long-term inflation expectations to changes in oil price futures over the same period are in both cases smaller and statistically insignificant.

[45]The results are robust to alternative measures of market-based inflation expectations: inflation compensation embedded in Treasury inflation-protected securities and Treasury inflation-protected securities break-even inflation rates cleaned of a liquidity premium, following Celasun, Mihet, and Ratnovski (2012).

Summary and Policy Implications

Inflation rates have declined substantially in a large number of countries in recent years, with several advanced economies experiencing outright deflation. The decline in inflation is widespread across sectors, but stronger for tradable goods. Its main drivers are persistent labor market slack and weaker import price growth. The results in the chapter suggest the latter are associated with falling commodity prices and widening industrial slack in a few key large economies, particularly in China. At the same time, the part of disinflation not explained by the Phillips curve has tended to become larger in the past few years, especially in advanced economies. This shortfall in inflation relative to model-based predictions could be a sign that price setters' inflation expectations have declined more than what is captured by survey-based measures used in the econometric analysis or that economic slack is larger in some countries.

The chapter finds that monetary policy frameworks play an important role in influencing the sensitivity of inflation expectations to inflation surprises. Improvements in these frameworks over the past few decades have led inflation expectations to be much better-anchored than in the past—although there is scope for further improvements in some emerging market economies.

However, the chapter's analysis also suggests that medium-term inflation expectations in advanced economies with constrained monetary policy have recently become more sensitive to unexpected movements in actual inflation or in commodity prices. Although the increase in this sensitivity is small, it does suggest that faith in central banks' ability to combat persistent disinflationary forces might be diminishing—this sensitivity should be zero if medium-term expectations are perfectly anchored. An implication of this finding is that in advanced economies where perceived monetary policy space is limited, medium-term inflation expectations could become unanchored in the event of further unexpected declines in inflation.

What do these findings imply for the inflation outlook in countries that have experienced sizable disinflation over the past few years? Since most measures of medium-term inflation expectations have not declined significantly and commodity prices are projected to gradually recover, the most likely outcome is a gradual recovery of inflation toward central bank targets as slack diminishes and the effect of past declines in commodity prices fades. But the increase in the sensitivity of inflation expectations to downside inflation surprises, the finding that inflation has become more persistent, and the possibility that slack might be larger than currently estimated in some countries, suggest downside risks to that central forecast. The possibility of a gradual further downward drift in medium-term inflation expectations and consequent prolonged period of low inflation is more than trivial in some countries.

The main findings of the chapter—the broad reach of the disinflation across countries, evidence of cross-border spillovers of disinflationary forces, the increased sensitivity of medium-term expectations to news, as well as the confluence of slack in many large economies—call for a comprehensive and coordinated effort to tackle the risks of low inflation. Given limited policy space in many economies, exploiting synergies between all available policy levers and across countries will be essential.[46]

- In countries with persistent economic slack and inflation consistently below central bank targets, it is crucial to maintain an appropriate degree of monetary accommodation to help keep medium-term inflation expectations anchored and ease the perception that monetary policy has become ineffective. While unconventional monetary policy actions taken in the aftermath of the Great Recession lifted inflation expectations (see footnote 5), estimates of natural interest rates have been revised down substantially over time, suggesting that monetary policy more recently may have been providing less accommodation than previously thought (see Chapter 1 of this WEO for a further discussion). Where medium-term inflation expectations appear to have shifted down, a more aggressive approach should be considered. In particular, a credible and transparent commitment to a modest and temporary overshooting of the inflation target would provide valuable insurance against deflationary and recessionary risks by reducing longer-term real rates even if the nominal policy rate is at the effective lower bound, generating a path of stronger demand and bringing inflation to target sooner (see Box 3.5; IMF 2016c; and Gaspar, Obstfeld, and Sahay forthcoming).
- Other policy levers need to be aligned with accommodative monetary policy in boosting demand.

[46]See Gaspar, Obstfeld, and Sahay (forthcoming) for a further discussion and case studies.

Given the broad-based nature of the disinflation and the corresponding fact that many countries are easing monetary policy at the same time, dampening the downward pressure that monetary policy easing exerts on the exchange rate, monetary policy stimulus on its own may not be sufficient to keep medium-term inflation expectations anchored at central bank targets. A comprehensive package consisting of a more growth-friendly composition of fiscal policy, an expansionary fiscal stance where fiscal space is available, demand-supportive structural reforms, and measures aimed at addressing weaknesses in bank and corporate balance sheets should play a complementary role in mitigating the risk of protracted weak demand and low inflation. Income policies could also be considered in countries with stagnant wages and entrenched deflationary dynamics to set in motion a healthy upward wage-price spiral.

- Distortionary policies that perpetuate overcapacity in tradables sectors should be avoided: they not only worsen resource allocation and, where financed by credit, weaken asset quality in the banking system, but they also exert disinflation pressure in the domestic economy that could spill over to other countries via import prices, reinforcing global disinflation pressures.[47]
- Finally, the breadth of the disinflation and evidence of meaningful cross-border spillovers of disinflationary forces through import prices also point to the value of a coordinated approach to supporting demand across the larger economies. Through positive spillovers, simultaneous action across countries would amplify the effects of each individual country's actions. A coordinated effort to simultaneously tackle weak demand and inflation in advanced economies and to redouble ongoing efforts to reduce overcapacity in countries with elevated industrial slack would be more impactful than a go-it-alone approach.

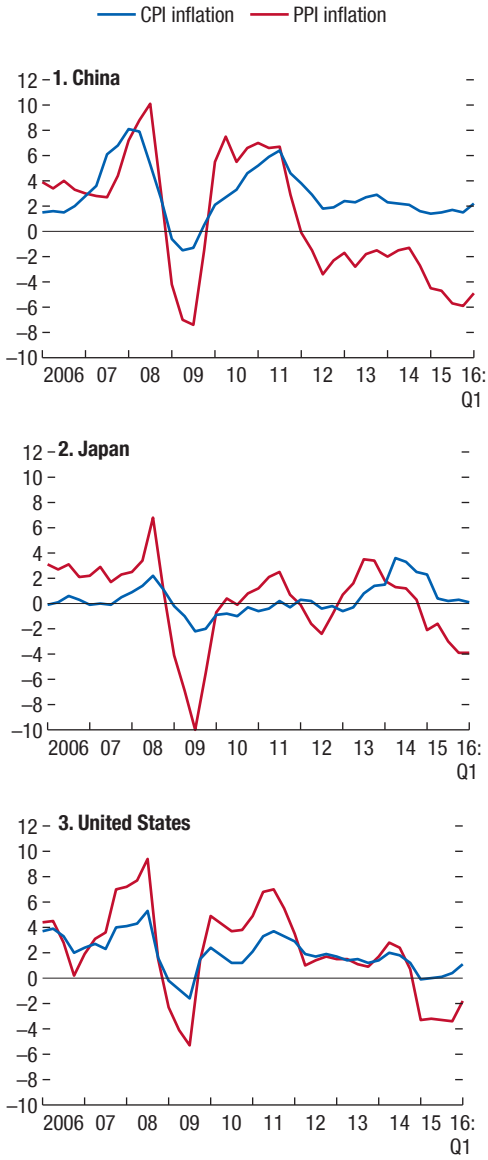
[47]In China, the authorities have already signaled their intent to address overcapacity, starting with the coal and steel sectors where capacity reduction targets have been set, together with the establishment of a fund to absorb the welfare costs for affected workers. Restructuring has begun at the local level in provinces with relatively strong public finances and more diverse economies (IMF 2016b).

Box 3.1. Industrial Slack and Producer Price Inflation

The recent decline in inflation has been much more pronounced in the manufacturing sector than in services. Consistent with this trend, an increasing body of evidence points to marked overcapacity in a range of industrial sectors, with industrial output growth decelerating significantly (National Association of Manufacturers 2016; Organisation for Economic Co-operation and Development 2015).[1] This box presents estimates of slack in the industrial sector in three large economies: China, Japan, and the United States.[2] All three economies have recently experienced outright declines in the producer price index (PPI) and generally subdued trends in consumer price inflation—although to varying extents (Figure 3.1.1). Estimates of slack—output gaps—for each economy as a whole, and separately for the industrial sector, are obtained through an extended multivariate filter that includes information on GDP, consumer price inflation, PPI inflation, and industrial production. The identification strategy relies on equations, for each economy separately, relating inflation to the estimated gaps.[3] The key equation resembles the standard Phillips curve but is confined to the industrial sector. It expresses PPI inflation as a function of the estimated industrial sector output gap; expected inflation; and leads and lags in headline inflation.

The results suggest that the industrial slack in the first quarter of 2016 stood at about 5.5 percent in China, 5 percent in Japan, and 3 percent in the United States (Figure 3.1.2). For China, the estimates incorporate a disaggregated treatment of light and heavy industry, derived from electricity consumption in the two subsectors. This shows a marked difference between slack in light industry (about 4.5 percent)

Figure 3.1.1. Producer Price and Consumer Price Inflation in China, Japan, and the United States
(Percent)



Source: IMF staff estimates.
Note: CPI = consumer price index; PPI = producer price index.

The authors of this box are Kevin Clinton, Zoltan Matyas Jakab, Douglas Laxton, and Fan Zhang.

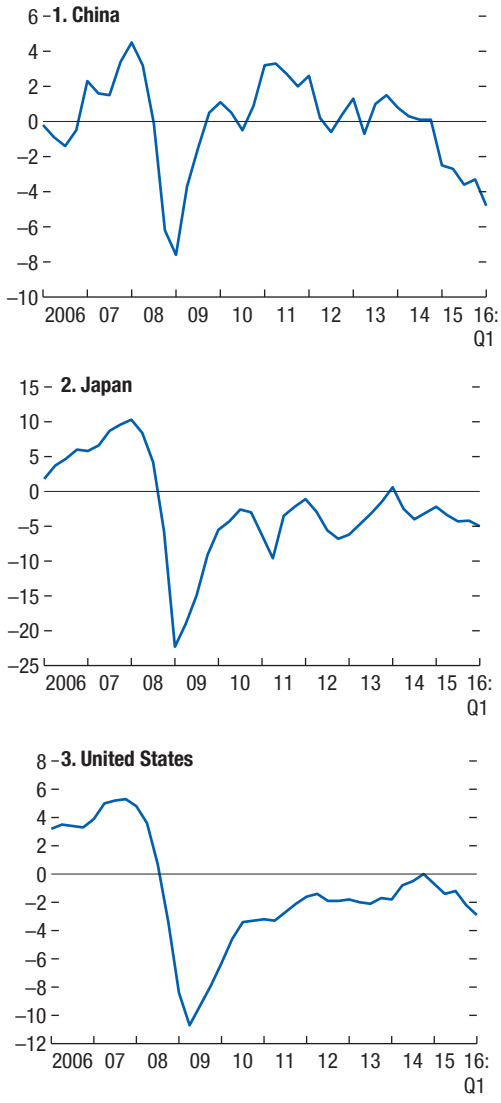
[1]Industrial production comprises manufacturing, mining, and utilities (with relative weights in the United States of 78 percent, 12 percent, and 10 percent, respectively). Total industrial output is used instead of manufacturing output because of limited data. Annual average industrial production growth in the United States fell from about 2.5 percent in 2011–13 to 0.3 percent during 2014:H2–2016:H1. In Japan and China, the growth rate decreased from 0.3 percent to –2.5 percent and from 10.7 percent to 6.3 percent, respectively, over the same period.

[2]Industrial production in China, Japan, and the United States accounts for 45 percent of total world industrial production (as of 2014 and at constant 2005 prices, according to the United Nations National Accounts Main Aggregates Database): United States (19 percent), China (18 percent), and Japan (8 percent).

[3]For details see Alichi and others (2015).

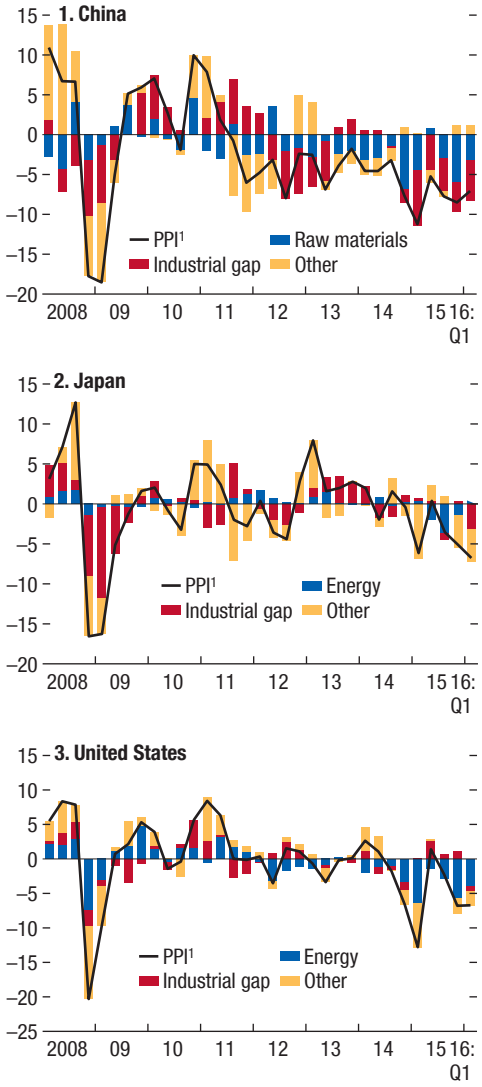
Box 3.1 *(continued)*

Figure 3.1.2. Industrial Slack in China, Japan, and the United States
(Percent)



Source: IMF staff estimates.

Figure 3.1.3. Decomposition for Total Producer Price Inflation for China, Japan, and the United States
(Annualized percentage points)



Source: IMF staff estimates.
Note: PPI = producer price index.
[1] Historical contribution of all shocks (difference between actual values and an unconditional forecast estimated using a vector autoregression model).

Box 3.1 *(continued)*

and in heavy industry (about 10.5 percent). In all three countries, the size of industrial slack correlates with the change in PPI inflation.

Although the filtering approach yields estimates of industrial slack consistent with the steep drop in PPI inflation rates, it does not allow for a decomposition of the relative contributions of various factors. For this purpose, the analysis uses structural vector autoregression models for PPI inflation that include the estimated industrial slack and energy or raw materials prices.[4] The historical decompositions of PPI inflation suggest that the energy shock (or raw material shock in China) has been a key driver of the recent decline in PPI inflation, especially in the United States (Figure 3.1.3). In China and Japan, however, industrial slack has also played an important role. In particular, the estimated contribution of the industrial slack to PPI deflation in China over the past four years is as large as that of raw materials prices.

[4]Producer prices for finished consumer energy goods were used as energy prices in the United States; the electric power, gas, and water component of the Domestic Corporate Goods Price Index was used in the case of Japan (both denoted as "Energy" in Figure 3.1.3). In the case of China, the raw materials component of the PPI was used and is denoted "Raw materials" in the figure. The identifying assumptions are that over the long term: (1) the relative price of energy or raw materials prices (vis-à-vis the PPI) is driven exclusively by energy and raw materials price shocks and not by shocks to industrial slack, (2) industrial slack is affected by both the "Industrial gap" and "Energy" or "Raw materials" shocks, and (3) PPI inflation is driven by all three shocks (Energy, Raw materials, Industrial gap, and by other PPI-specific shocks).

Box 3.2. The Japanese Experience with Deflation

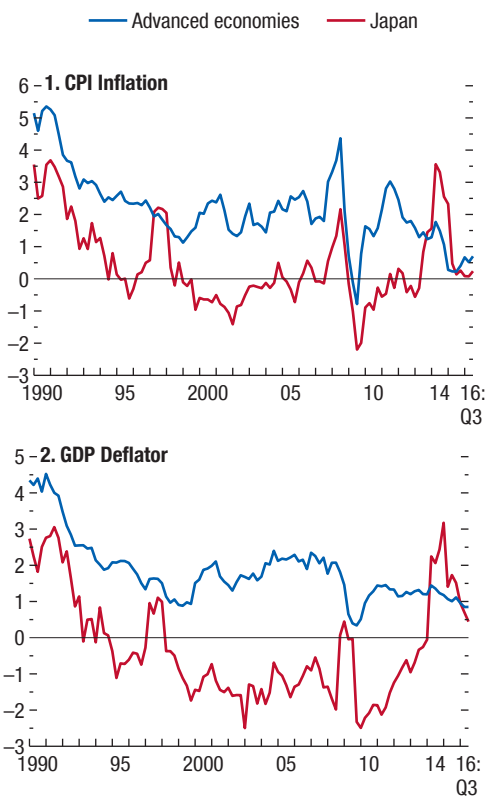
The Japanese economy has experienced weak inflation for most of the past two decades. Inflation measured by the GDP deflator has been particularly low, averaging –0.3 percent between 1990 and 2015 compared with 0.5 percent for consumer price inflation (Figure 3.2.1). Continued efforts to reflate the economy have so far fallen short, highlighting the difficulty in escaping a deflation trap once expectations are anchored around a deflation equilibrium. A great deal of literature has sought to identify the causes and consequences of Japan's deflation experience, offering useful insights into the current disinflation trend in many economies. This box attempts to shed light on the following questions: What drove the Japanese deflation episode that started in the mid-1990s? How has it affected the Japanese economy? How relevant is the Japanese experience to the current disinflation trend?

Drivers of Deflation

The bursting of the asset price bubble in the early 1990s is often mentioned as the initial shock leading Japan into deflation. Inflation and inflation expectations declined gradually as efforts by households, banks, and businesses to strengthen balance sheets and rebuild net worth suppressed demand (IMF 2014; Koo 2008). Supply-side shifts and exchange rate appreciation were also highlighted as factors contributing to deflation momentum during this period (Leigh 2010; Posen 2000). The external shock from the 1997–98 Asian Crisis further weakened demand, and a slow response to the problem of nonperforming loans resulted in a banking crisis, tipping the economy into deflation in 1998. The commodity price boom that started in the early 2000s pushed headline inflation up, offering some temporary relief, but core inflation remained in negative territory (Figure 3.2.1). Further shocks, such as the bursting of the information technology bubble and the 2008–09 global financial crisis, reinforced weak demand, and the output gap remained negative (Figure 3.2.2). The yen appreciation leading up to the introduction of Abenomics in 2013 and the commodity price decline since 2014 have further complicated efforts to reflate the economy.[1] While there has been some recent success in raising core inflation, deflation risks are rising again amid low demand and declining inflation expectations.

Structural factors exacerbated the effect of demand shocks, feeding into deflation pressure. Several of these factors are relevant for many advanced economies today: a decline in labor's bargaining power and an aging and slow-growing population. The decline in labor's bargaining power—evident in the trend fall in unit labor costs starting in the late 1990s (Figure 3.2.2)—together with firms' sluggishness, as seen in large corporate cash holdings, are argued to have

Figure 3.2.1. Inflation Dynamics
(Year-over-year percent change)



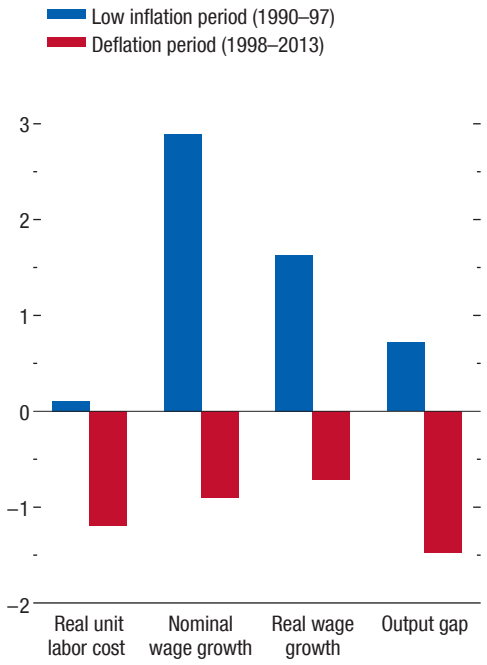
Source: IMF staff calculations.
Note: Quarterly seasonally adjusted data are used and weighted by purchasing-power-parity GDP to aggregate for advanced economies. Advanced economies comprise Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong SAR, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan Province of China, the United Kingdom, and the United States. CPI = consumer price index.

The authors of this box are Elif Arbatli, Samya Beidas-Strom, and Niklas Westelius.

[1]See the main chapter text for an analysis of the impact of commodity prices on headline inflation.

Box 3.2 *(continued)*

Figure 3.2.2. Cyclical and Structural Indicators in Japan
(Average annual percent change)



Sources: Organisation for Economic Co-operation and Development; and IMF staff calculations.

fed deflation by weakening wage-price dynamics (Porcellacchia 2016). Firms became less likely to hire workers on permanent contracts ("regular workers") in an environment of low expected growth. The share of regular workers among salaried employees fell over this period, contributing to lower unit labor costs, permanent income, and benefits for employees. Japan's aging and declining population growth have also been blamed for deflationary pressure as lower potential growth, and its implication on fiscal sustainability, are cited as holding back demand (Anderson, Botman, and Hunt 2014). At the same time, the aging population could also lead to excess demand and inflation pressure since retirees tend to consume more than they produce (Juselius and Takáts 2015)—even though the net effect of aging on inflation is ambiguous.

The timidity and low credibility of the policy response during the 1990s have also been widely cited as contributors to deflation. In particular, the pace and extent of the initial monetary easing were likely insufficient, and the fiscal policy response has been criticized as ineffective in stimulating growth (Bernanke and Gertler 1999; Ito and Mishkin 2006; Kuttner and Posen 2002; Leigh 2010). The fiscal position remained broadly accommodative throughout the period of deflation (Figure 3.2.3, panel 1), but periodic attempts at consolidation also led to stop-and-go implementation of fiscal policy (Kuttner and Posen 2002; Syed, Kang, and Tokuoka 2009), and its effectiveness was stymied by lack of coordination with monetary policy (Eggertsson 2006). In addition, the Bank of Japan was moving toward independence and a price stability mandate in the 1990s, with an explicit inflation target introduced only in 2013.[2] As a result, long-term inflation expectations in Japan were not well anchored in the 1990s (Figure 3.2.3, panel 2), making the economy more vulnerable to deflation shocks. Finally, cleaning up weak financial sector balance sheets took long and inhibited financial intermediation, contributing to a prolonged recession and deflation pressure (Ito and Mishkin 2006).

Impact of Deflation and Relevance Today

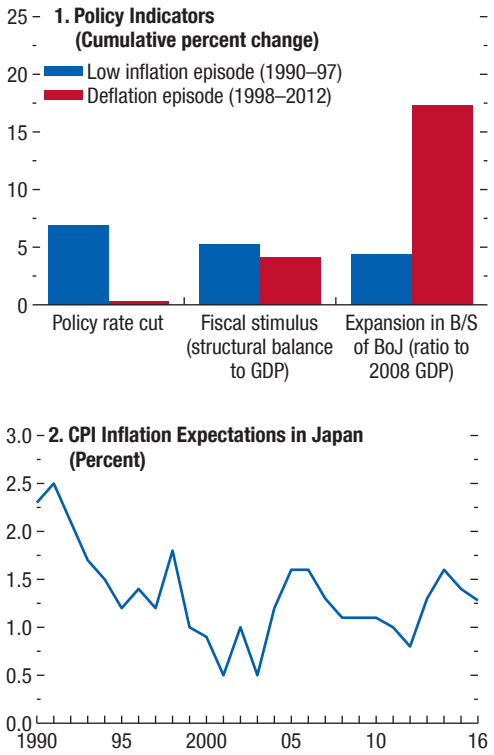
Sustained deflation is generally believed to have acted as a headwind for the Japanese economy. Firms became more reluctant to invest and hire regular workers, and consumers postponed purchases of durable goods in anticipation of future price declines. A vicious cycle of declining prices, decreasing profits, and wage restraint reinforced weak demand in a "coordination failure" (Kuroda 2013). The increase in borrowers' real debt burden raised default risk and reduced asset prices, collateral valuations, and credit intermediation to the real economy. Deflation supported a shift in portfolio allocations toward so-called safe assets, reducing the supply of risk capital.

Persistently weak growth in the GDP deflator, and hence in nominal GDP, worsened the interest-rate-growth differential and contributed to a higher debt

[2]Measures of central bank credibility (Crowe and Meade 2007; Dincer and Eichengreen 2014) suggest that the Bank of England, the Federal Reserve, and the European Central Bank, for example, ranked higher (on policy transparency) going into the global financial crisis than Japan during both its low-inflation and deflation episodes.

Box 3.2 *(continued)*

Figure 3.2.3. Policy Indicators in Japan



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: Inflation expectations are the 10-year forecast from Consensus Economics; the policy rate is the uncollateralized average overnight call rate. BoJ = Bank of Japan; B/S = balance sheet; CPI = consumer price index.

burden (End and others 2015).[3] On the monetary side, as nominal interest rates reached their effective lower bounds and inflation expectations declined, real interest rates could not be lowered sufficiently, contracting the economy further. Despite the large expansion in the Bank of Japan's balance sheet through unconventional monetary operations in recent years, inflation remains stubbornly low.

In sum, the Japanese experience underscores the importance of credible, decisive, and strong policy responses to prevent inflation expectations from becoming unanchored. The impact of persistent deflation can be large, and once deflation expectations emerge, it may be difficult to push the economy out of the liquidity trap. Structural factors in many advanced economies, including a secular decline in labor's bargaining power, could generate additional headwinds.[4]

[3]While it is difficult to quantify the impact of deflation on debt accumulation, a mechanical calculation assuming a zero inflation rate for the years with deflation alone suggests a contribution of about 36 percent of GDP since 1990 through automatic debt dynamics.

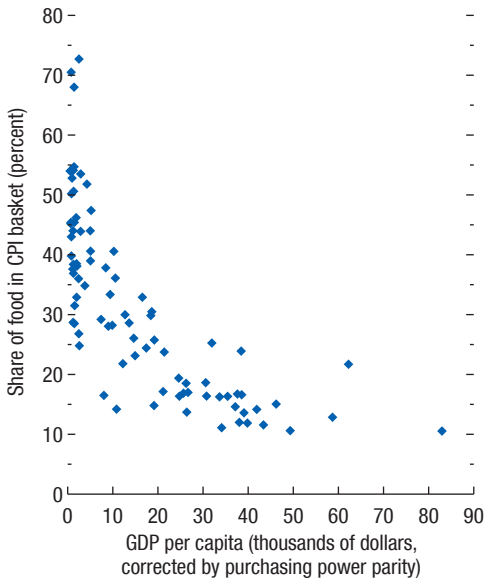
[4]IMF (2016a) and Arbatli and others (2016) discuss the potential role for income policies and labor market reforms to strengthen wage-price dynamics in Japan.

Box 3.3. How Much Do Global Prices Matter for Food Inflation?

Bursts of inflation have often been accompanied or preceded by spiraling food prices.[1] This partly reflects the sizable share of food in consumption, particularly in lower-income countries (Figure 3.3.1). Waning global food prices since 2011 have therefore rekindled interest in the extent to which changes in international food prices pass through to domestic food prices and thus put downward pressure on overall consumer price inflation.

Comparing changes in world prices with changes in the domestic price of food in more than 80 economies, however, points to a low correlation between them.[2] Indeed, the patterns of domestic food inflation are strikingly different from inflation patterns in world food markets (which are denominated in U.S. dollars). In many advanced and especially emerging market economies, such a decoupling reflects exchange rate depreciation relative to the U.S. dollar, which has limited or more than offset the decline in world food prices (Figure 3.3.2, panels 1 and 2). By contrast, the exchange rate has played a lesser role in many low-income developing economies. The rapid increases in domestic food prices in these economies were driven by higher inflation in local food production, which is mostly nontradable (Figure 3.3.2, panel 3). Overall, food inflation has been generally higher than nonfood inflation in all country groups, especially in sub-Saharan Africa and emerging market economies (Figure 3.3.3). Thus, domestic food inflation has generally offset the ongoing nonfood deflationary pressures in many economies.[3]

Figure 3.3.1. Food Weights in Consumption and per Capita GDP



Source: IMF staff calculations.
Note: CPI = consumer price index.

Evidence of limited pass-through from free-on-board (that is, excluding the transportation cost to the final national market destination) food prices to consumer food prices is corroborated by regression analysis for a sample of 81 countries using monthly data for 2000–15 (Figure 3.3.4).[4] Despite the

The authors of this box are Emre Alper, Luis Catão, Niko Hobdari, Daniel Te Kaat, and Ali Uppal.

[1]A statistical horse race between food and oil prices as leading indicators of worldwide inflation over the past four decades points to a prominent role of food over oil (Catão and Chang 2011). For instance, the great inflation of the 1970s was preceded by a faster pace of food inflation relative to both oil and overall consumer prices. The first post–World War II outburst of global inflation in the 1950s was preceded by rising inflation in food commodities but not in oil. More recently, the widespread rise in consumer price index inflation above central bank targets in 2007–08 was largely due to food rather than oil.

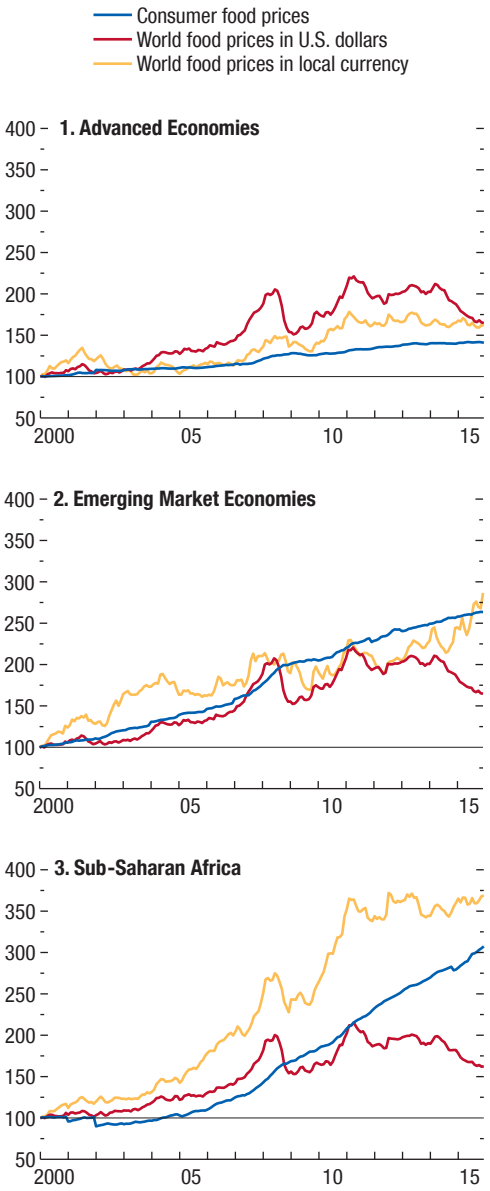
[2]The analysis uses country-specific weights to compute the equivalent world market price of the domestic food consumption basket—that is, the price that consumers of that country would pay if they were to buy that approximate commodity basket in the world market. For sub-Saharan Africa, data availability allowed this computation for 17 of the 41 countries, with mean weights of low-income countries and middle-income countries of that sample applied to the entire sample. The analysis focuses on free-on-board import prices in local currency to control for exchange rate movements.

[3]On average, food inflation exceeded nonfood inflation by 1.4 percentage points a year during 2010–15 in the 41 sub-Saharan African countries comprising the sample. In advanced and emerging market economies, the respective differentials are 0.8 percentage point and 0.5 percentage point during the same period.

[4]The explanatory variables in the individual country regressions are the current and up to six lags of the free-on-board food price inflation index in local currency (computed as the percentage change of the product of the world food price index in U.S. dollars and the country's exchange rate against the U.S. dollar), augmented by lags of domestic food price inflation (with the lag length for each country regression being determined by standard statistical criteria). The pass-through coefficient is then computed as the sum of the coefficients on the free-on-board food inflation divided by 1 minus the sum of the lagged domestic food inflation coefficients (that is, the autoregressive coefficients).

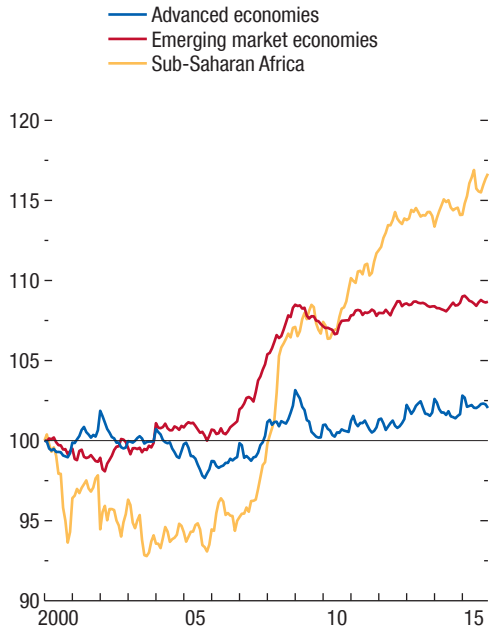
Box 3.3 *(continued)*

Figure 3.3.2. World Food Prices and Consumer Food Prices
(January 2000 = 100)



Source: IMF staff calculations.

Figure 3.3.3. Food Prices Relative to Nonfood Prices
(January 2000 = 100)

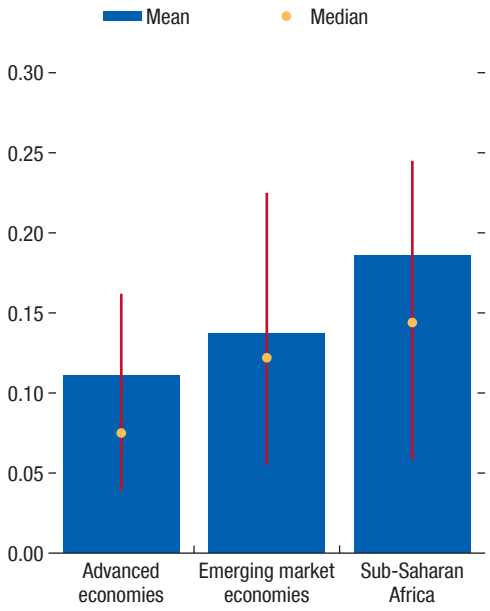


Source: IMF staff calculations.

mass of the distribution of the pass-through coefficients being centered between 0.1 and 0.2 (the median is about 0.12), there is considerable variation across countries. The pass-through is close to 0.4 for some countries and larger than 1 for one outlier (Ethiopia). In general, sub-Saharan Africa not only has a higher average pass-through but also higher cross-country dispersion of pass-through coefficients than advanced and emerging market economies. In addition, when the sample is broken into two subperiods—the first comprising the high food price inflation of 2006–08 and the second the decline in world food prices of 2009 and from 2011 onward—the pass-through appears to be higher on average and more dispersed in the former period (Figure 3.3.5). To explain the dispersion of pass-through coefficients across countries and periods, a regression of the various pass-through coefficients obtained from the full sample period is run on a variety of factors, including those identified by previous studies (for example, Gelos and Ustyugova 2012). The results of this empirical exercise point to the role of

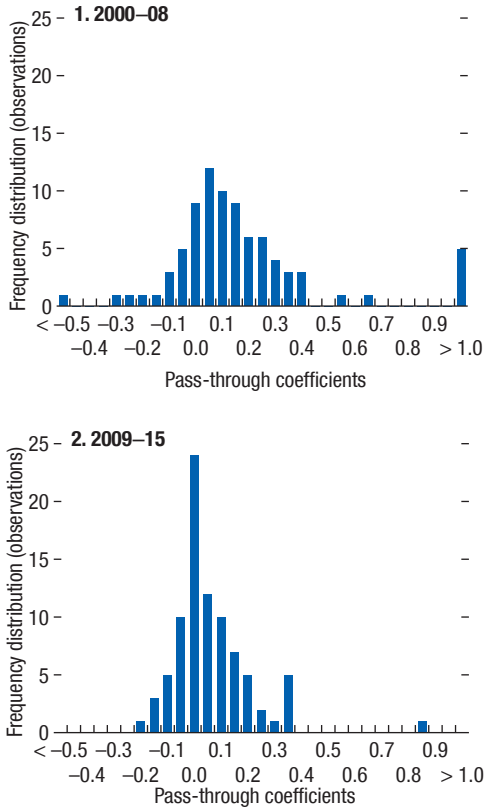
Box 3.3 *(continued)*

Figure 3.3.4. Food Pass-Through Coefficients for Various Country Groups



Source: IMF staff calculations.
Note: Vertical lines denote interquartile ranges.

Figure 3.3.5. Distribution of Food Pass-Through Coefficients



Source: IMF staff calculations.

income levels, exchange rate regimes, openness to food trade, and output volatility in shaping pass-through coefficients (Table 3.3.1):

- *Higher per capita income is associated with lower international food price pass-through.* One explanation for this result is that richer countries on average consume food products with higher value added, for which nontradable components, such as distribution services, represent a larger share of the overall cost.
- *A more stable exchange rate regime is associated with a higher pass-through.* With a fixed exchange rate, free-on-board prices in local currency are a more direct reflection of world prices, mitigating deviations from the law of one price associated with unexpected exchange rate volatility.
- *Countries that are either large net exporters (that is, with food exports exceeding food imports) relative to GDP or larger net importers of food relative to GDP are characterized by higher pass-through.* The rationale for this result is that the tradable component of domestic food is likely to increase with either net food exports or net food imports.
- *Countries with higher average tariff rates on agricultural products have a lower pass-through*, consistent with the notion that tariffs reduce the tradability of some domestic food items.
- *The pass-through is higher in countries where growth is more volatile.* There may be different explanations for this finding. One straightforward explanation is that more volatile economies display less price stickiness, so the pass-through from higher world food prices to retail food prices is higher.

These findings suggest that a low pass-through of international to domestic food prices might not necessarily enhance welfare. This may be, for instance, the case if the pass-through is low as a result of high

Box 3.3 *(continued)*

Table 3.3.1. Cross-Country Determinants of Pass-Through of Free-on-Board Food Prices to Food Consumer Price Inflation

	(1)	(2)
Log of per Capita GDP	–0.0385***	–0.0333***
	(–3.15)	(–3.31)
Openness	0.0174	
	(0.88)	
Food Trade Balance/GDP	0.00838*	
	(1.71)	
Food Trade Balance/GDP, Squared	0.00124***	0.00151***
	(3.72)	(3.88)
Average CPI Inflation	–0.00135	
	(–1.34)	
Exchange Rate Regime	0.0296**	0.0235*
	(2.3)	(1.96)
Average Agricultural Tariff	–0.00527**	–0.00741***
	(–2.39)	(–4.90)
Growth Volatility	0.0116*	0.0134**
	(1.68)	(2.08)
Quality of Institutions	–0.00484	
	(–0.88)	
Constant	0.168***	0.151***
	(3.32)	(3.06)
Number of Observations	81	81
R^2	0.564	0.517
Adjusted R^2	0.509	0.484

Sources: IMF, National authorities; and IMF staff estimates.
Note: The dependent variable is the estimated pass-through coefficient reported in Figure 3.4. Robust *t*-statistics are in parentheses. CPI = consumer price index. ***, **, * denote significance at the 1, 5, and 10 percent level, respectively.

tariffs that distort resource allocation, or if it reflects a high share of local produce (such as fresh fruits and vegetables) that—given its nontradability—is produced, stored, or transported inefficiently.[5] Indeed, when world prices are falling, low tradability limits the benefits of falling world food prices to consumers. Conversely, when world food prices are rising, low tradability tends to limit the benefits of higher world prices to producers and thus postpone needed adjustments to production, which would eventually benefit domestic consumers as well.

[5]See Chapter 1 for evidence on the share of local produce in domestic food consumption and a broad discussion of the role of food in production and consumption.

Box 3.4. The Impact of Commodity Prices on Producer Price Inflation

The chapter documents a generalized decline in producer price inflation across advanced economies over the past few years, especially in manufacturing. The drop in producer price inflation has been particularly marked among commodity importers, suggesting that international input linkages are a key channel through which deflation pressure spills across countries (Figure 3.4.1). Against this backdrop, this box uses sectoral data from four selected advanced economies—France, Germany, Korea, and the Netherlands—to explore how much of the decline in producer price inflation can be attributed to weakening international commodity prices and other import prices.[1]

The empirical approach used to decompose the contribution of different input prices to sector-level producer price inflation follows the methodology developed in Ahn, Park, and Park (2016). In particular, the following specification is used to estimate the effect of domestic input prices (DOM_{it}), imported input prices (IMP_{it}), and labor costs (ULC_{it}) on domestic producer prices (P_{it}) at the country-sector level:[2]

$$ln(P_{it}) = \beta_1 \alpha_{i,DOM} ln(DOM_{it}) + \beta_2 \alpha_{i,IMP} ln(IMP_{it}) + \beta_3 \alpha_{i,ULC} ln(ULC_{it}) + \varepsilon_{it}, \quad (3.4.1)$$

in which it denotes sector i at time t, ln denotes logs, and $\alpha_{i,X}$ is the share of each type of input in the total cost structure of sector i (with $\sum_X \alpha_{i,X} = 1$), obtained from input-output tables.[3] The degree of pass-through from input prices to producer prices (β) is allowed to vary across inputs to account for a possible heterogeneous response to underlying cost shocks. The equation is estimated separately in panel settings for Korea (including sector fixed effects) and for the three European economies (with country-sector fixed effects). An error correction setup is used to take into account the potential cointegrating relationship between nonstationary producer and input prices.

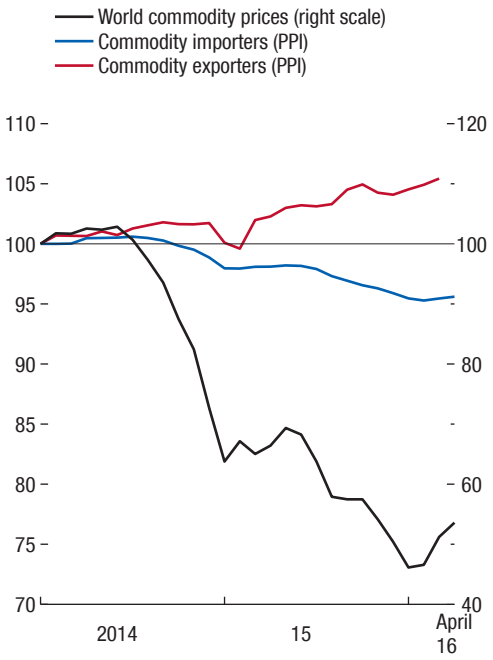
Following the novel approach in Ahn, Park, and Park (2016) and Auer and Mehrotra (2014), input-output tables and sector-level price data are combined to construct input price and labor cost indices for each domestic sector i. For instance, the imported input price index for sector i is obtained as:

$$ln(IMP_{it}) = \sum_j (\alpha_{ij,IMP}/\alpha_{i,IMP}) ln(I_{jt}), \quad (3.4.2)$$

in which $\alpha_{ij,IMP}$ is the share of imported inputs from sector j in total inputs used for sector i's production from input-output tables, and I_{jt} is the price index of sector j imported goods from sector-level import price data.[4] Imported inputs can be further split into

Figure 3.4.1. Commodity Prices and Producer Prices

(January 2014 = 100; simple average by country groups)



Sources: Bank of Korea; Eurostat; Haver Analytics; and IMF, International Financial Statistics database.
Note: Commodity importers: 18 euro area countries, China, Japan, Korea, United Kingdom, United States; Commodity exporters: Brazil, Chile, Colombia, South Africa. PPI = producer price index.

The author of this box is JaeBin Ahn.

[1]The focus on these four advanced economies is based on high-frequency sector-level price data availability.

[2]A possible limitation of the methodology is that prices in other sectors as well as exchange rates—which affect import prices denominated in local currency—are taken as given in the estimation. Also, by relying on a reduced-form specification, the analysis does not take a stand on the underlying source of variation in commodity or other imported input prices.

[3]The source for input shares is the World Input-Output Table (http://www.wiod.org/).

[4]All the price series data are available from the Statistics Database at the Bank of Korea (Economic Statistics System), which is publicly accessible on the Web (ecos.bok.or.kr), or from the Eurostat database (http://ec.europa.eu/eurostat/data/database).

Box 3.4 *(continued)*

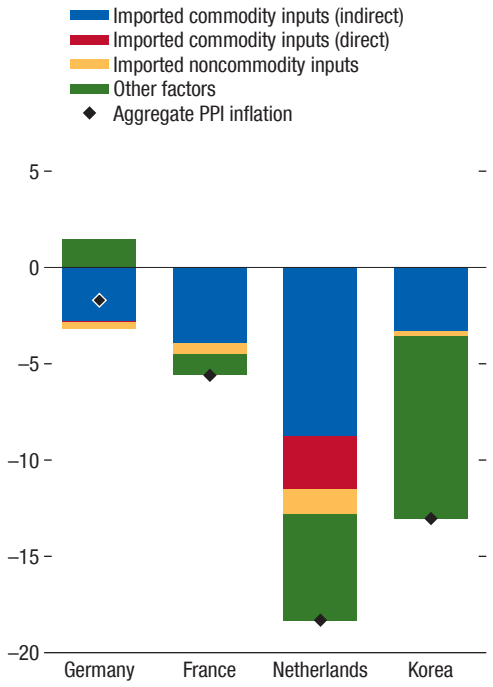
commodity and noncommodity components, allowing for separate estimation of their contributions to producer price inflation.[5] The sector-specific domestic input price and unit labor cost indices are constructed analogously using input-output tables, sector-level domestic producer price indices, and sector-level unit labor cost indices.

The results suggest that the pass-through from import prices to domestic producer prices is high. The short-term pass-through from commodity to domestic producer prices in Korea is about 40 percent and reaches about 60 percent over the long term. The pass-through from commodity input prices is even higher in the three European countries—90 percent in the short term and almost 100 percent in the long term.[6] The estimated pass-through coefficients from noncommodity import prices are comparable.

Combining these pass-through estimates with actual sector-level import prices over the past two years suggests the following results:

- The sharp drop in commodity prices was a major driver of aggregate producer price deflation in France, Germany, and the Netherlands over the past two years (Figure 3.4.2). Its contribution was somewhat smaller but still important in the case of Korea.
- The differences across countries in the relative contribution of commodity import prices to aggregate producer price inflation are mostly due to variations in input weights—rather than to differences in import price dynamics.
- Most of the impact of commodity prices on aggregate producer price deflation during this period is indirect—stemming from a decline in input prices for domestic noncommodity sectors. The direct contribution—through commodity imports by the domestic commodity sector—is almost zero in all countries except the Netherlands where oil re-exports are significant—and even there it accounts for only one-fifth of the total commodity price contribution.
- The contribution of noncommodity import prices to aggregate producer price inflation over the past two years is much smaller. This is mainly due to the fact that international manufacturing prices declined much less than international commodity prices over the past two years—rather than due to differences in pass-through coefficients or differences in the relative weights of commodity versus noncommodity inputs in production.

Figure 3.4.2. Contribution to Cumulative Producer Price Inflation
(Percent, January 2014–March 2016)



Sources: Bank of Korea; Eurostat; Haver Analytics; IMF, International Financial Statistics database; and IMF staff calculations.
Note: The direct contribution of imported commodity inputs captures the commodity sector's own use of imported commodities, and the indirect contribution reflects other sectors' use of imported commodities as inputs. PPI = producer price index.

[5]The commodity sector is defined as the "mining and quarrying" industry at the two-digit industry classification.

[6]The difference in the estimated coefficients across country groups might reflect, among other factors, distinct market structures and degree of competition.

Box 3.5. A Transparent Risk-Management Approach to Monetary Policy

A risk-management approach to monetary policy seeks to avoid severe outcomes, including deflation. Policymakers do not worry about small deviations from desired outcomes but they attach an increasing marginal cost to inflation and output gap deviations as they grow larger. This implies prompt and aggressive actions to move the economy away from situations in which the risk of conventional policy instruments losing their effectiveness becomes larger—such as in a context of persistent economic slack and low inflation with the policy interest rate at the effective lower bound (ELB).

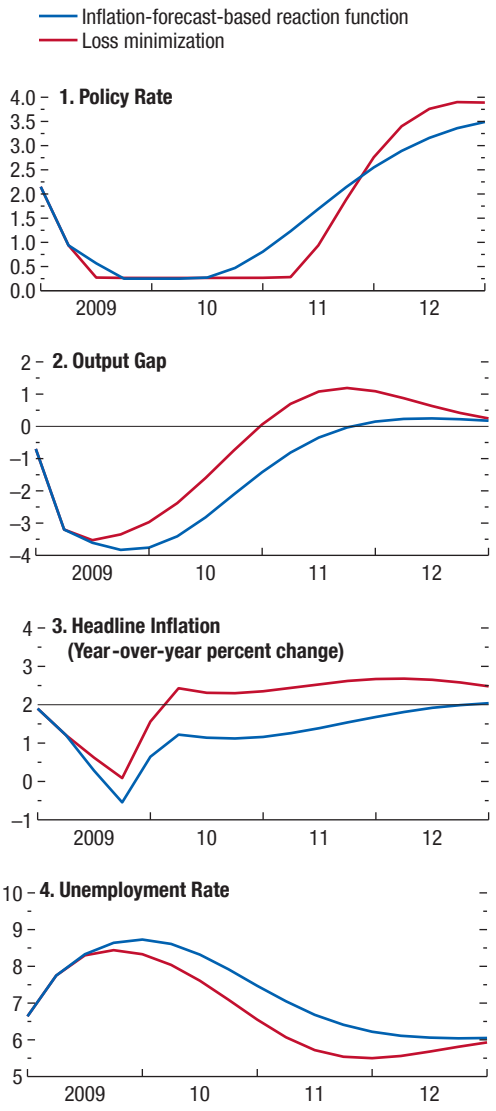
Expectations play a crucial role in the effectiveness of monetary policy. Adjusting the central bank's conventional policy instrument—a very short-term interest rate—in itself has a negligible effect on the overall economy. Its impact stems from its influence over market expectations about the future path of short-term interest rates which, in turn, affect the medium- and longer-term interest rates at which households and firms invest and borrow.

However, the path for policy interest rates that can bring inflation to the central bank's target is not unique. For example, the central bank may intend to pursue a strategy that returns inflation to target gradually, with small steps in the policy instrument over a period of several quarters. Or it may be planning a quick, aggressive approach. In the absence of direct guidance from policymakers, market expectations will not necessarily match the central bank's intended path for policy rates.

This box presents model simulations to illustrate how a credible and transparent commitment to aggressive monetary accommodation can reduce the risk of recession and deflation even if the monetary policy rate is at the ELB.[1] A standard New Keynesian model of the Canadian economy is used to simulate a counterfactual repeat of the history of the global financial crisis under two alternative policy strategies. In the first strategy, based on the principle of risk management, the central bank minimizes a loss function imposing a steeply increasing marginal cost on output gaps and deviations of inflation from the target. The second policy strategy follows a linear inflation forecast–based policy reaction function—that is, a forward-looking Taylor rule. The counterfactual simulated scenarios start in the second quarter of 2009 and are summarized in Figure 3.5.1:

- The risk-management strategy (red line) implies holding the policy rate at the ELB (assumed here to be 0.25 percent) until the first quarter of 2011, long enough to result in a temporary overshooting

Figure 3.5.1. Forecast as Envisaged at 2009:Q2: Loss Minimization versus Linear Reaction Function
(Percent, unless noted otherwise)



Source: IMF staff estimates.

The authors of this box are Kevin Clinton, Douglas Laxton, and Hou Wang.

[1]See Obstfeld and others (forthcoming) for further details.

Box 3.5 *(continued)*

of the inflation target. As the public is aware of this intention, expectations for longer-term nominal interest rates shift down and medium-term inflation expectations increase. This reduces real interest rates, which in turn increases asset prices and depreciates the local currency, boosting output and inflation. The inflation overshoot makes up for the initial undesired well-below-target inflation and, on average, inflation ends up being very close to the target.

- The linear policy reaction function plan (blue line), in contrast, implies raising the policy rate already by mid-2010 and a much slower convergence to the target—en route, this means wider output gaps and deviations of inflation from the target and higher unemployment than under the risk-management strategy.

The logic for a more aggressive strategy that deliberately overshoots the inflation target is straightforward. Further negative demand shocks in a context of policy rates already at the ELB pose the risk of pushing the economy into a deflation situation from which escape is increasingly difficult. Relative to this, the prospect of a short period with inflation above target is acceptable.

But transparency is a key ingredient of this strategy. Publishing the expected path of all the variables used at policy decision meetings, including the projected path for the policy interest rate, would help the central bank give a credible public account of its strategy.[2] This would reinforce public confidence in the central bank's inflation objective and strengthen the transmission of policy actions to the economy: if the published path for policy interest rates is credible, the term structure of interest rates and asset prices, such as the exchange rate, will move in support of the policy objectives. In contrast, forecasting an overshooting of the inflation rate without communicating the whole breadth of the central bank's strategy might undermine confidence in the nominal anchor—it might look as though the central bank is doing "too little, too late" in terms of normalizing interest rates.

[2]See Poloz (2014) for arguments in favor of forward guidance, including by publishing the projected path of policy rates, when interest rates are at the effective lower bound but not in normal times.

Annex 3.1. Sample and Data

Country Sample

The broadest sample used for regression analysis in this chapter comprises 44 advanced and emerging market economies, listed in Annex Table 3.1.1. These economies are selected based on the availability of their inflation expectation measures from the Consensus Forecasts database.

Data Sources

The primary data sources for this chapter are the Organisation for Economic Co-operation and Development Economic Outlook and Structural Analysis databases, CEIC China database, Consensus Economics Consensus Forecasts database, Global Data Services database, IMF World Economic Outlook database, World Bank World Development Indicators database, and Haver Analytics and Bloomberg L.P. All variables are of quarterly frequency (with the exception of the variables used in the analysis of market-based inflation expectations, which are available at daily frequency). Medium-term inflation expectations from the Consensus Forecasts database are interpolated to quarterly frequency from biannual surveys. The coverage of GDP and import price deflators is expanded by interpolation from annual data. Annex Table 3.1.2 lists all indicators used in this chapter as well as their sources.

Annex 3.2. Model Simulations

Model simulations are used to assess the deflationary effects of depressed demand and subdued import prices in three large economies—the United States, the euro area, and Japan—when monetary policy is constrained and inflation expectations become unanchored.[48] The simulations are carried out under two alternative macroeconomic environments. In both environments, monetary policy is assumed to be constrained—that is, the policy rate is at its effective lower bound. The second assumes, in addition, that inflation surprises have a direct effect on inflation expectations.[49]

[48]Simulations are performed using the IMF's G20MOD model.

[49]The effect of inflation on inflation expectations is introduced in the model via shocks to the expected inflation term that enters the model's reduced-form Phillips curve. An inflation surprise equal to 1 percentage point that occurs in year 1 would shift inflation expectations by 0.25 percentage point in year 2, 0.10 percentage point in year 3, 0.05 percentage point in year 4, and would decline to zero in year 5 and beyond. These magnitudes are based on the empirical evidence in the chapter on the degree to which inflation surprises shift the private sector's inflation expectations at various horizons.

Annex Table 3.1.1. Sample of Advanced and Emerging Market Economies

Advanced Market Economies	Emerging Market Economies
Australia, Canada, Czech Republic, Estonia, France, Germany, Hong Kong SAR, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan Province of China, United Kingdom, United States	Argentina, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, Thailand, Turkey, Ukraine, Venezuela

Annex Table 3.1.2. Data Sources

Variable	Source
Commodity Prices	Bloomberg L.P., Haver Analytics, IMF Commodity Price System
Consumer Price, Core Consumer Price, Producer Price, and Wage Indices	Haver Analytics; IMF, World Economic Outlook database; Organisation for Economic Co-operation and Development
Import Value, Import Volume, and Import-Price Deflator	CEIC database; Haver Analytics; IMF, World Economic Outlook database; Organisation for Economic Co-operation and Development; World Development Indicators database
Industrial Production Index	IMF, World Economic Outlook database
Nominal and Real GDP, and GDP Deflator	Haver Analytics; IMF, World Economic Outlook database; Organisation for Economic Co-operation and Development; World Development Indicators database
Nominal Effective Exchange Rates	Global Data Services database
Output Gap	IMF, World Economic Outlook database
Unemployment Rate	Bloomberg L.P.; Haver Analytics; IMF, World Economic Outlook database; Organisation for Economic Co-operation and Development; Thomson Reuters Datastream
Inflation Swaps, Stock Market Indices, and Treasury Bill Interest Rates	Bloomberg L.P.; Haver Analytics
Survey-Based Inflation Expectations	Bank of England, Survey of External Forecasters; Consensus Economics; European Commission, Business and Consumer Surveys; IMF, World Economic Outlook database; University of Michigan, Survey of Consumers
Unemployment Expectation	Consensus Economics
Central Bank Transparency and Governor Turnover Rate	Crowe and Meade (2007)
Inflation-Targeting Regime	*World Economic Outlook*, October 2011, Chapter 3

The first shock considered in the simulations is a temporary decline in domestic demand of 1 percent in each of the three economies. The results reported in Figure 3.4 show that even if monetary policy is constrained, the economy would escape from the deflation trap within a reasonable timeframe as long as inflation expectations remained well anchored. But if inflation expectations drifted down, it could take a very long time for the economy to emerge from deflation.

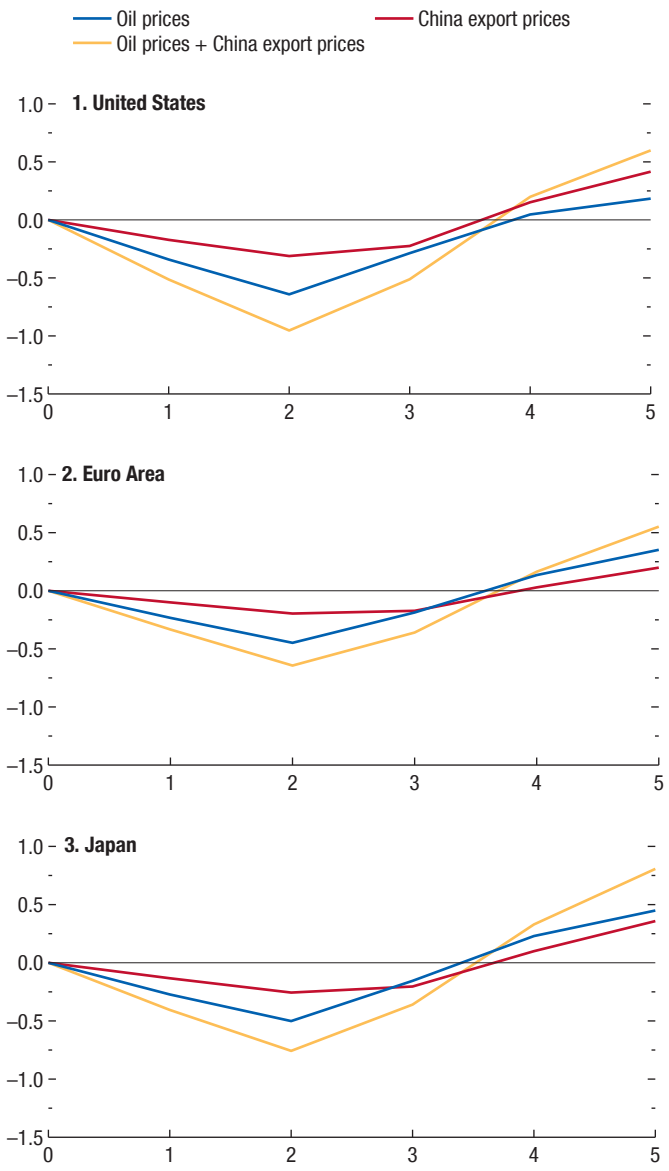
The results in the chapter suggest that reduced import prices have also played an important role in driving inflation down in many economies over the recent past. While in normal circumstances import prices typically have temporary effects on inflation and therefore should not be a source of concern for inflation dynamics going forward, they could be potentially worrisome at the current juncture of constrained monetary policy and evidence of inflation expectations becoming unanchored.

To gauge the possible deflationary consequences of these developments, two shocks to import prices are considered. The first shock is a sharp decline in oil prices.[50] The second shock is a decline in China's export prices—taken as an example of a shock to global prices of tradable goods stemming from manufacturing slack in a key large economy.[51] The results reported in Annex Figures 3.2.1 and 3.2.2 show that shocks to import prices may lead to persistent disinflation pressure when monetary policy is constrained and medium-term inflation expectations become unanchored:

- *Constrained monetary policy*—In countries with constrained monetary policy, lower prices for oil and manufactured goods from China may keep inflation below the baseline—that is, the path in the absence of shocks—for up to four years (Annex Figure 3.2.1). A decline in import prices directly reduces inflation in the short term but also indirectly reduces it through lower demand. The indirect effect arises from lower inflation interacting with the unchanged nominal policy rate: real interest rates rise, putting downward pressure on both consumption and investment. However, in the medium term, the decline in import prices raises households' wealth, which stimulates consumption enough to more than offset the downward pressure exerted by higher real interest rates. Higher consumption

Annex Figure 3.2.1. Effect of Disinflationary Shocks on Core Inflation in Advanced Economies under Constrained Monetary Policy

(Percentage points; years after the shock on x-axis)

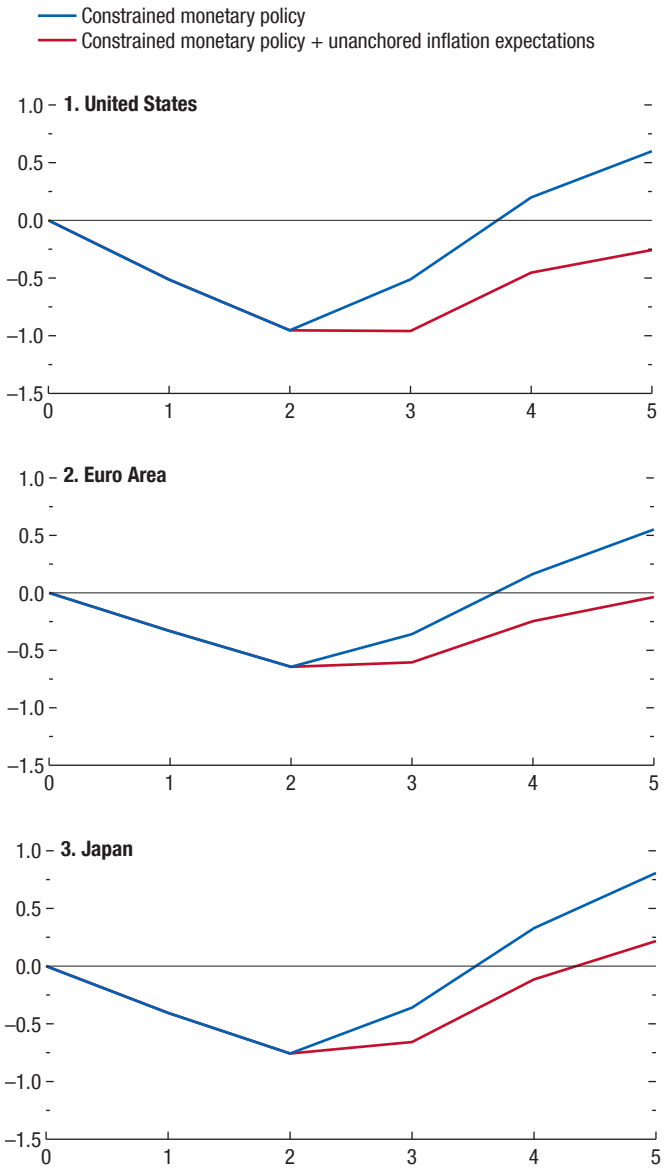


Source: IMF staff estimates.
Note: The figure reports the responses of core inflation after a shock to international oil prices and a shock to China's export prices. The model assumes that conventional monetary policy is constrained at the effective lower bound on nominal interest rates in all countries.

[50]The shock to oil prices is calibrated so that its magnitude matches the actual drop in international oil prices in 2014 and its persistence is consistent with prices in the futures market.

[51]The decline in China's export prices has been set to broadly match the impact of excess capacity in China on consumer price inflation in key advanced economies in 2015 documented in the chapter.

Annex Figure 3.2.2. Effect of Disinflationary Shocks on Core Inflation in Advanced Economies under Constrained Monetary Policy and Unanchored Inflation Expectations
(Percentage points; years after the shock on x-axis)



Source: IMF staff estimates.
Note: The figure reports the responses of core inflation after a combined shock to international oil prices and China's export prices. The model assumes that conventional monetary policy is constrained at the effective lower bound on nominal interest rates in all countries. The alternative scenario (red line) assumes also that inflation expectations are affected by inflation shocks.

demand and lower input costs also stimulate investment. The resulting increase in domestic demand is eventually sufficient to halt and then reverse the decline in inflation. The effect of lower import prices on inflation varies by economy depending on (1) its degree of dependence on oil imports, (2) the extent of its trade links with China, (3) the wealth effect generated by lower import prices, and (4) the degree of flexibility in wages and prices.

- *Constrained monetary policy and unanchoring of inflation expectations*—If monetary policy is constrained and inflation expectations become unanchored, lower import prices may lead to persistent disinflation. Inflation rates remain below the baseline for more than five years (Annex Figure 3.2.2). The result is driven by additional deflation pressure stemming from lower inflation expectations, which may more than offset the positive inflation effects associated with increased household wealth effects in the medium term. The results of this scenario suggest that if inflation expectations become unanchored, mitigating the impact of declining import prices on core inflation could be quite challenging without additional measures to stimulate demand.

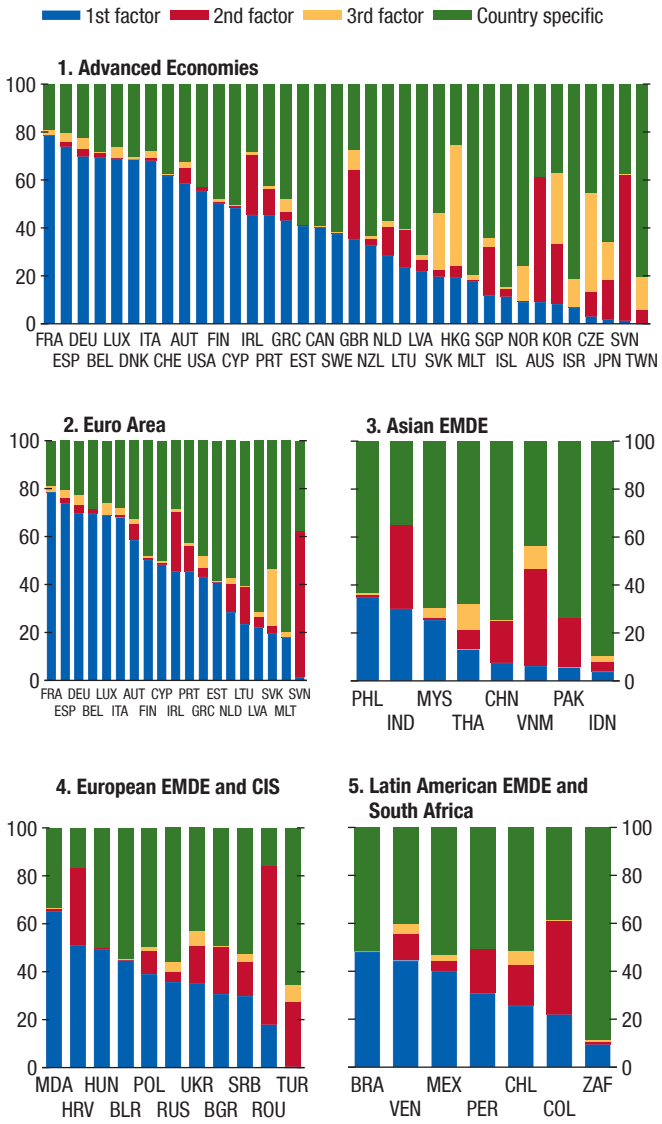
Annex 3.3. Principal Component Analysis

A principal component analysis is used to assess the extent to which the recent decline in inflation is common across countries.[52] The results of the analysis suggest that the first three common factors explain about 80 percent to 90 percent of the variation in inflation among advanced economies in 2000–08 and 2009–15, respectively, and about 75 percent among emerging market and developing economies in both subperiods. There is, nonetheless, significant heterogeneity across countries in the importance of these factors. For example, common factors play a larger role in France and Spain, while country-specific factors play a larger role in countries such as Iceland, Israel, and South Africa (Annex Figure 3.3.1).

While numerous variables may be correlated with the first three common factors, the evolution over time of the first common factor, for instance, is closely related to changes in commodity prices

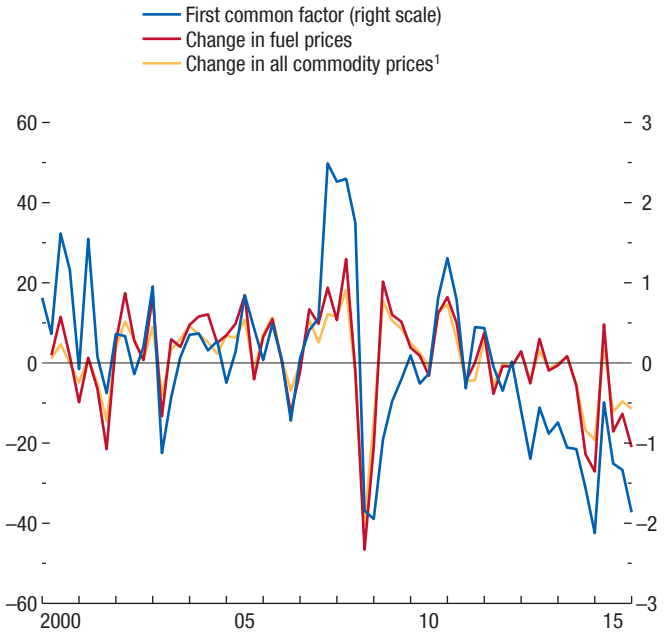
[52]The principal component analysis is a statistical procedure that transforms the data into a set of values of linearly uncorrelated variables—principal components. See Rabe-Hesketh and Everitt (2007).

Annex Figure 3.3.1. Share of Consumer Price Inflation Variation Explained by Different Factors
(Percent)



Sources: Haver Analytics; and IMF staff estimates.
Note: CIS = Commonwealth of Independent States; EMDE = emerging market and developing economies. Data labels in the figure use International Organization for Standardization (ISO) country codes.

Annex Figure 3.3.2. First Common Factor and Commodity Prices
(Percent)



Sources: Haver Analytics; IMF, Primary Commodity Prices database; and IMF staff estimates.
[1] Price index using weights based on 2002–04 average world export earnings.

(Annex Figure 3.3.2).[53] Additional analyses using Bayesian modeling average and weighted least squares find that, indeed, commodity prices stand out among several variables—including slowing global industrial production, growth disappointments in emerging market economies, and financial market conditions—as being strongly linked with the first common factor.

[53]See the April 2015 *Regional Economic Outlook: Asia and Pacific* and the IMF's *2015 Spillover Report* (IMF 2015) for similar evidence.

Annex 3.4. Drivers of the Recent Decline in Inflation

Empirical Framework

The following version of the Phillips curve equation is estimated:

$$\pi_t = \gamma_t \pi^e_{t+h} + (1 - \gamma_t)\,\tilde{\pi}_{t-1} + \theta_t u^c_t + \mu_t \pi^m_t + \varepsilon_t, \quad (3.4.1)$$

in which π_t denotes annualized quarterly headline consumer price inflation, π^e_{t+h} denotes inflation expectations h years ahead (with 10-year-ahead expectations used in the baseline specification), $\tilde{\pi}_{t-1}$ is the moving average of inflation over the previous four quarters, u^c_t denotes cyclical unemployment, π^m_t denotes the relative price of imports (defined as the import-price deflator relative to the GDP deflator), and ε_t denotes the residual.

The coefficients and the nonaccelerating inflation rate of unemployment (NAIRU) are assumed to follow constrained random walks ($\gamma_t \in (0,1), \theta_t < 0$,

$\mu_t > 0$, and no restrictions on NAIRU). Cyclical unemployment is assumed to follow an AR(1) process: $u_t^c = \rho u_{t-1}^c + \varepsilon_t^u$, with $u_c^t = u_t - u_t^*$, in which u_t denotes the unemployment rate, u_t^* denotes the NAIRU, and ε_t^u is assumed to follow $N(0, \sigma_u^2)$.

The model is estimated country-by-country using maximum likelihood based on a constrained nonlinear Kalman filter for a sample of 44 advanced and emerging market economies from the first quarter of 1990 to the first quarter of 2016.

An important feature of the model is that it allows for time variation in all parameters to capture changes in the structure of each economy. The advantages of such a model compared with rolling regressions are fourfold: (1) it uses all observations in the sample to estimate the magnitude of the parameters in each year—which by construction is not possible in rolling regressions; (2) changes in the parameters in a given period come from innovations in the same period, rather than from shocks occurring in neighboring periods; (3) it reflects the fact that economic structures typically change slowly and depend on the immediate past; and (4) it allows for possible nonlinearities (Swamy and Mehta 1975).

Decomposition

The decomposition of inflation dynamics is conducted in a way similar to Yellen (2015). The exercise is constructed in terms of deviations of inflation from inflation targets—using the average of 10-year-ahead inflation expectations during 2000–07 as a proxy for inflation targets. The contribution of each explanatory variable is obtained by setting its value to zero and comparing the model's prediction with that when all explanatory variables are set at their historical values.[54] The contribution of import prices to inflation is further decomposed into the contribution of import prices in U.S. dollars and variations in the domestic exchange rate vis-à-vis the U.S. dollar. The contribution of labor market slack is computed by substituting the cyclical unemployment series estimated with the Kalman filter—and possibly subject to end-sample bias—with a measure derived from output gap estimates in the IMF World Economic Outlook database and country-specific Okun's law coefficient estimates reported in Ball, Furceri, and Loungani (forthcoming); the residuals are adjusted accordingly. The simulation is dynamic in that the lagged inflation term is set to its simulated values. Therefore, the decomposition incorporates the effects of changes in lagged inflation that are attributable to previous movements in the explanatory variables—which become more relevant as inflation is more persistent.

Robustness Checks

Inflation expectations measure—The baseline specification is estimated using 10-year-ahead inflation expectations from Consensus Economics, for two reasons: (1) long-term inflation expectations are a close proxy for central banks' inflation targets, so that the parameter γ can be interpreted as the degree to which the headline inflation is linked to the central bank's target—a phenomenon typically referred to as "level anchoring" (Ball and Mazumder 2011) and (2) long-term inflation expectations are less correlated with current and lagged inflation and hence are less subject to problems of multicollinearity and reverse causality.

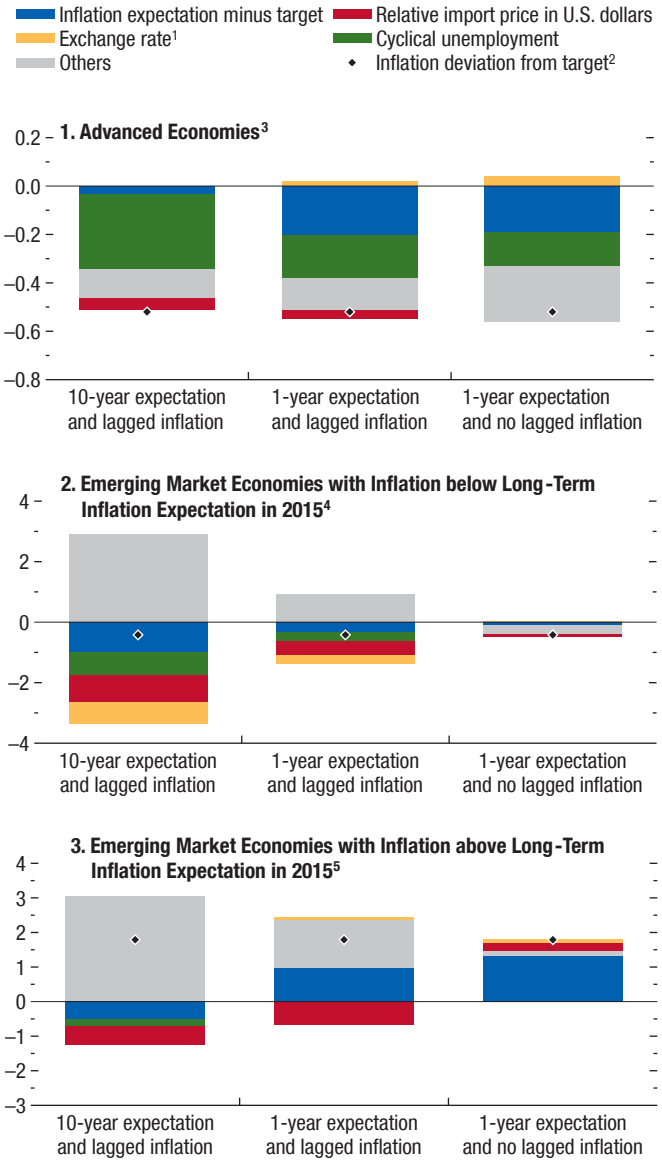
To test for the robustness of the results, two alternative versions of equation (3.4.1) are estimated. The first uses 1-year-ahead inflation expectations instead of 10-year-ahead expectations. The second one uses 1-year-ahead inflation expectations but omits the lagged inflation term. For advanced economies, the results are broadly similar to those obtained in the baseline (Annex Figure 3.4.1, panel 1).[55] In emerging market economies, however, using shorter-term expectations results in substantially smaller residuals, especially in countries with inflation above long-term expectations (Annex Figures 3.4.2, panels 2 and 3).

Cyclical unemployment measure—Estimates of cyclical unemployment are typically subject to large uncertainty. To check the robustness of the results, two alternative estimates of cyclical unemployment are used: (1) the Hodrick-Prescott filtered unemployment rate and (2) deviations of unemployment rates from five-year moving averages. The results presented in Annex Figure 3.4.2 suggest that the contribution of import prices to inflation is robust to alternative proxies of economic slack, but the contribution of slack itself and other factors varies somewhat when different measures are used.

[54]The analysis assumes that labor market slack and import prices do not affect 10-year-ahead inflation expectations, which is supported by additional analysis of the effect of these two variables on inflation expectations.

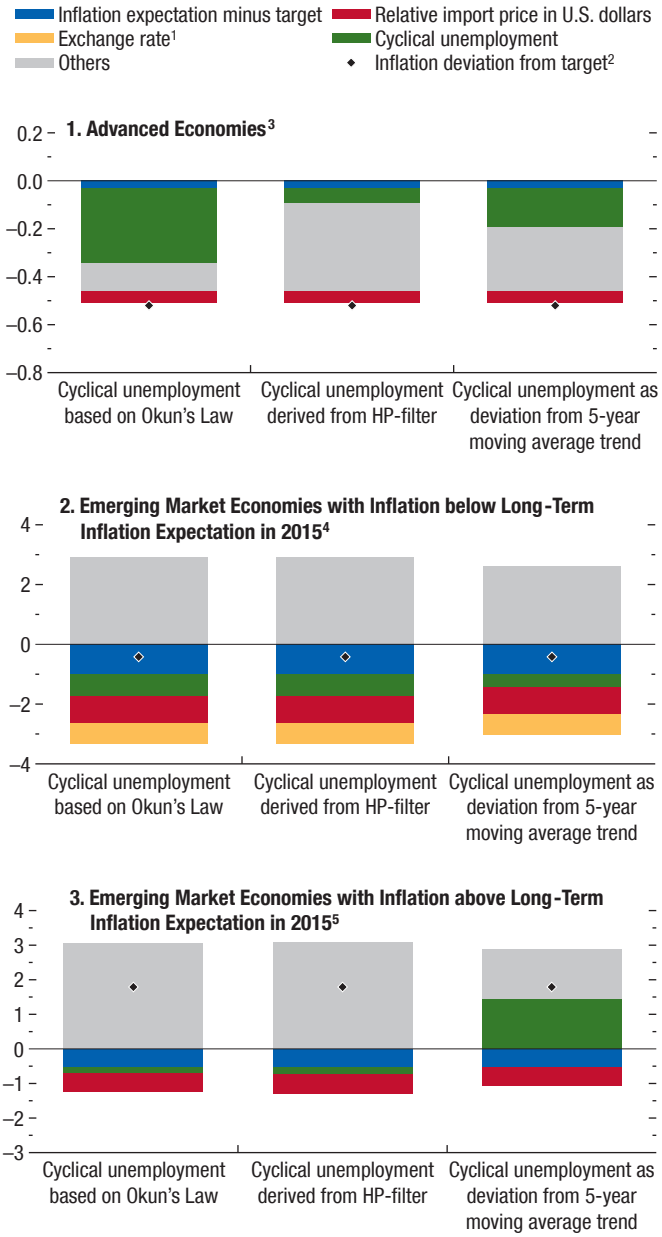
[55]The results of two-year- or three-year-ahead inflation expectations (not reported here due to space constraints) are broadly similar to those of one-year-ahead inflation expectation.

Annex Figure 3.4.1. Contribution to Inflation Deviations from Targets Using Various Measures of Inflation Expectations



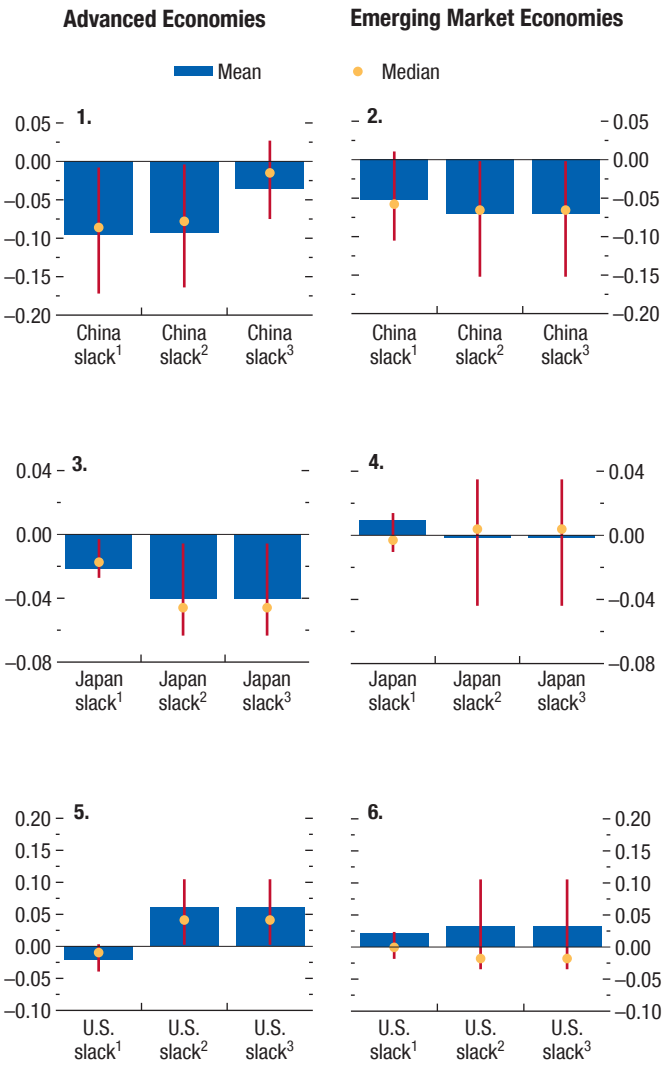
Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development, Economic Outlook database; and IMF staff calculations.
Note: The figure reports average contributions in 2008–15. Okun's law coefficients come from Ball and others 2016.
[1] Exchange rate is defined as currency value per U.S. dollar.
[2] The target is defined as the average of 10-year inflation expectation in 2000–07.
[3] Advanced economies in Annex Table 3.1.1. Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia are excluded as outliers.
[4] Bulgaria, China, Hungary, Malaysia, Mexico, Philippines, Poland, Romania, Thailand.
[5] Argentina, Brazil, Chile, Columbia, India, Indonesia, Peru, Russia, Turkey.

Annex Figure 3.4.2. Contribution to Inflation Deviations from Targets Using Various Measures of Cyclical Unemployment



Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development, Economic Outlook database; and IMF staff calculations.
Note: The figure reports average contributions in 2008–15. Okun's law coefficients come from Ball and others 2016.
[1] Exchange rate is defined as currency value per U.S. dollar.
[2] The target is defined as the average of 10-year inflation expectation in 2000–07.
[3] Advanced economies in Annex Table 3.1.1. Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia are excluded as outliers.
[4] Bulgaria, China, Hungary, Malaysia, Mexico, Philippines, Poland, Romania, Thailand.
[5] Argentina, Brazil, Chile, Columbia, India, Indonesia, Peru, Russia, Turkey.

Annex Figure 3.4.3. Correlation of Manufacturing Slack in China, Japan, and the United States with Import Price Contribution to Inflation in Other Economies



Sources: Consensus Economics; Haver Analytics; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Vertical lines denote interquartile ranges. The figure shows the coefficients of manufacturing slack from regressions of the import price contribution to inflation on manufacturing slack and other variables.
[1] No controls.
[2] Controlling for manufacturing slack in the other two economies, change in oil prices, and global output gap.
[3] Controlling for global output gap and change in oil prices in current and previous four quarters.

Manufacturing Slack in China, Japan, and the United States, and Inflation in Other Economies

To explore the relationship between manufacturing slack in key large economies—China, Japan, and the United States—and inflation developments in other countries, the following equation is estimated for each of the 44 advanced and emerging market economies in the sample:

$$I_{i,t} = \alpha + \beta S_t^j + \delta X_t + \varepsilon_{i,t}, \qquad (3.4.2)$$

in which I is the contribution of import price to inflation as estimated using equation (3.4.1); S denotes manufacturing slack; j refers to China, Japan, or the United States; and X is a set of control variables, including global factors such as current and past changes in oil prices and global output gap—defined as the U.S.-dollar-GDP-weighted average of the output gap across countries.[56]

The results of the analysis suggest that the contribution of import prices to inflation in many advanced and emerging market economies is significantly correlated with manufacturing slack in China, Japan, and the United States. The association is particularly strong, robust, and more precisely estimated for China. In particular, a 1 percentage point increase in manufacturing slack in China is, on average, associated with a decline in inflation in other economies of about 0.04 percentage point to 0.1 percentage point (Figure 3.14), with the relationship being stronger in advanced economies than in emerging market economies (Annex Figure 3.4.3).

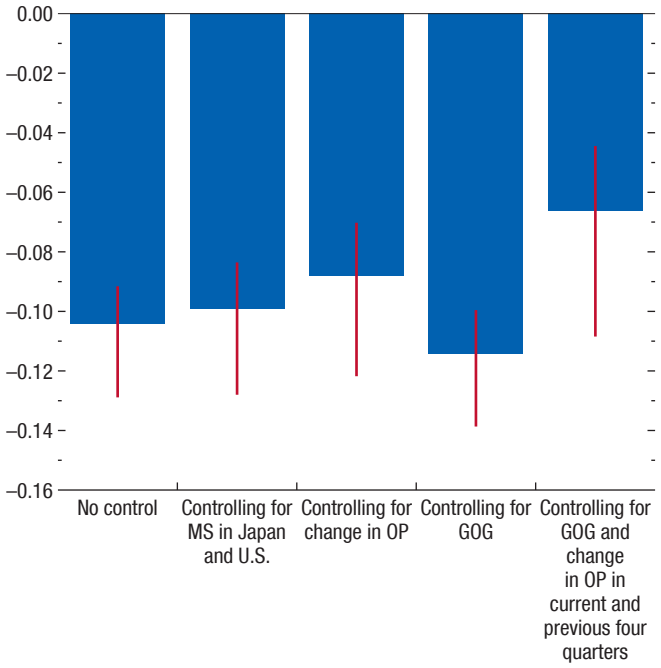
Equation (3.4.2) is also estimated in a panel setting with country-fixed effects. The results show that the correlation with manufacturing slack in China is significant at the 90 percent confidence interval and robust to controlling for global variables (Annex Figure 3.4.4). Finally, further analysis finds that this correlation is higher in countries with stronger trade links with China, providing additional evidence of spillover effects through tradable goods.

Annex 3.5. The Effect of Inflation Shocks on Inflation Expectations

The econometric approach to assess the effect of inflation shocks on inflation expectations follows the one used in Levin, Natalucci, and Piger (2004), which relates changes in inflation expectations to changes

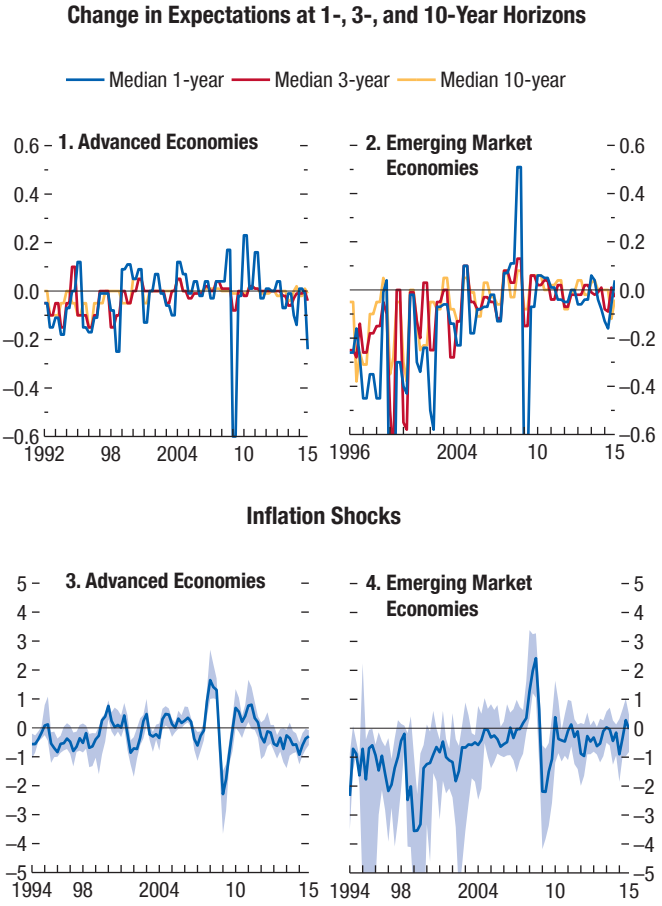
[56]The contribution of import prices to inflation is used as a dependent variable to provide a direct measure of the association between excess capacity in manufacturing in large economies and inflation rates in other advanced and emerging market economies. Similar results are obtained when import prices are used as the dependent variable (and the effect of manufacturing slack on inflation is computed by rescaling the effect of manufacturing slack on import prices by the effect of import prices on inflation).

Annex Figure 3.4.4. Correlation of China Manufacturing Slack with Import Price Contribution to Inflation in Other Economies: Results from Panel Regressions



Sources: Consensus Forecasts; Haver Analytics; Organisation for Economic Co-operation and Development, Economic Outlook database; and IMF staff calculations.
Note: The figure reports the coefficients of manufacturing slack in China from panel regressions. Bars denote coefficient median values. Vertical lines denote 90 percent confidence intervals. MS = manufacturing slack; OP = oil prices; GOG = global output gap.

Annex Figure 3.5.1. Change in Inflation Expectations and Inflation Shocks
(Percentage points)



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: Data used in this figure are quarterly. In panels 3 and 4, blue lines denote the median of inflation shocks, and shaded areas denote interquartile ranges.

in inflation. In particular, the following equation is estimated country by country:

$$\Delta\pi^{e}_{t+h} = \beta^{h}_{t}\pi^{news}_{t} + \epsilon_{t+h}, \qquad (3.5.1)$$

in which $\Delta\pi^{e}_{t+h}$ denotes the first difference in expectations of inflation h years in the future; π^{news}_{t} is a measure of inflation shocks—defined as the difference between actual inflation and short-term inflation expectations from Consensus Economics; and the coefficient β^{h} captures the degree of anchoring in h-years-ahead inflation expectations—a term usually referred to as "shock anchoring" (Ball and Mazumder 2011).

Annex Figure 3.5.1 shows the evolution of the left-hand-side (top panel) and right-hand-side (bottom panel) variables in equation (3.5.1) for advanced and emerging market economies. Changes in inflation expectations have been more volatile at shorter horizons for both groups of countries. Expectations were on a downward path throughout the 1990s in both advanced and emerging market economies as monetary frameworks were improving and inflation was falling. This trend was particularly strong in emerging market economies. Inflation expectations have been remarkably stable throughout the 2000s in advanced economies, especially at longer horizons, but recently their volatility has increased. In contrast, for emerging market economies the volatility of expectations during 2009–15 has been lower than in the previous decade.

Inflation shocks have been relatively modest in advanced economies, except for the period surrounding the global financial crisis. These shocks were mostly negative in the 1990s as inflation was declining, but have been close to zero in the 2000s. Since 2011, the

median inflation shock in advanced economies was negative. In emerging market economies, inflation shocks were negative on average in the 1990s and early 2000s, but less so more recently.

Robustness Checks

It is possible that changes in current and expected inflation are both driven by changes in expectations about the future state of the economy. For example, if firms and households expect that the economy will be in a recession in the near future and inflation will be lower than today, they will start cutting their consumption and investment expenditures now, putting downward pressure on inflation today. In that case, both inflation expectations and inflation would decline, but this would be driven by a third factor (expectations of future slack), rather than a causal link from inflation shocks to inflation expectations—especially on short-term horizons.

To check whether the results are simply driven by this mechanism, the baseline specification is augmented with the change in expectations about the future state of the economy, proxied by the change in one-year-ahead unemployment rate expectations from Consensus Forecasts (Δu^{e}_{t+1}):[57]

$$\Delta\pi^{e}_{t+h} = \beta^{h}_{t}\pi^{news}_{t} + \delta_{t}\Delta u^{e}_{t+1} + \epsilon_{t+h}. \qquad (3.5.2)$$

The results reported in Annex Figure 3.5.2 suggest that the sensitivity values obtained controlling for expectations about future slack are not statistically different from those presented in the baseline.

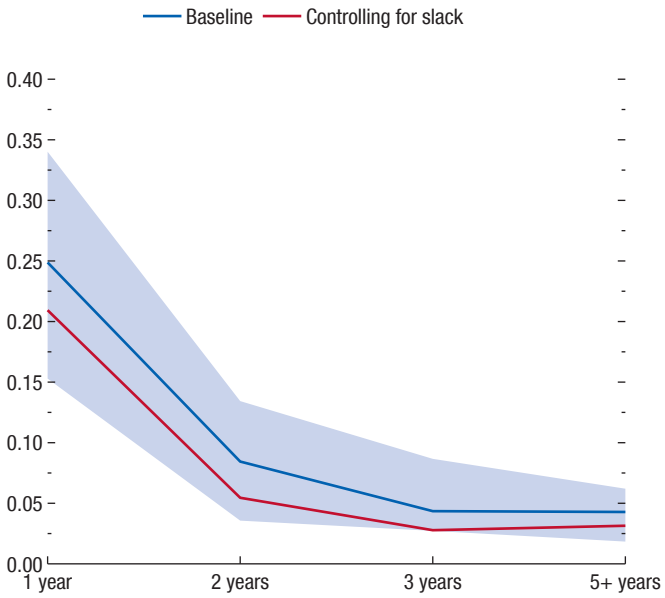
Finally, the results are also robust when considering changes in inflation or deviations of inflation from targets as alternative measures of inflation shocks.

Oil Price Inflation versus Core Inflation

For countries with a zero-lower-bound constraint, the sensitivity of inflation expectations to shocks is further decomposed into those originating from changes in: (1) oil price inflation and (2) core inflation. To do this, inflation surprises are first regressed on oil price inflation country by country:

[57]While it would be preferable to include the change in expectations of the unemployment rate at the same horizon as inflation expectations on the left-hand side, such data are not available. Moreover, even one-year-ahead unemployment rate expectations are collected only for 12 advanced economies; therefore, the sample in this robustness check is smaller than that in the main part of the analysis.

Annex Figure 3.5.2. Sensitivity of Inflation Expectations when Controlling for Slack: Advanced Economies



Sources: Consensus Economics; Haver Analytics; and IMF staff calculations.
Note: The figure shows the response of inflation expectations at various horizons to a 1 percentage point unexpected increase in inflation based on coefficients from country-specific static regressions. The alternative specification (red line) controls for the change in one-year-ahead unemployment rate expectations. The sensitivity for 5+ years corresponds to the average of estimations using 5- and 10-year-ahead inflation expectations. Solid lines denote the median response of inflation expectations across countries while the shaded area denotes the interquartile range of the responses under the baseline specification.

$$\pi^{news}_{t} = \alpha + \beta\,\pi^{oil}_{t} + \epsilon_{t}, \qquad (3.5.3)$$

in which π^{oil}_{t} is the oil price inflation. Inflation shocks are then decomposed into the part driven by changes in oil prices (fitted values) and the part unrelated to oil prices (residuals). Finally, the following equation is estimated for countries with policy rates at their effective lower bounds over the period 2009–15:[58]

$$\Delta\pi^{e}_{t+h} = \alpha + \vartheta\,\pi^{news,oil}_{t} + \gamma\,\pi^{news,core}_{t} + \epsilon_{t+h}, \qquad (3.5.4)$$

in which $\pi^{news,oil}_{t}$ denotes the inflation shocks driven by changes in oil prices, and $\pi^{news,core}_{t}$ is the inflation shocks unrelated to changes in oil prices.

This analysis suggests that the sensitivity of three-year-ahead inflation expectations to oil price shocks over the recent past in countries facing the effective-lower-bound constraint was very similar

[58]Zero-lower-bound economies are defined as advanced economies whose policy rates or short-term nominal interest rates were 50 basis points or lower at some point during 2009–15.

to that of core inflation shocks. Both sensitivities were around 0.03. The qualitative pattern remains the same when examining inflation expectations at longer-year horizons (five years and beyond) and overall commodity prices instead of oil prices. The results imply that inflation expectations did not become unanchored solely because of the sharp drop in oil and other commodity prices.

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