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CROSS-COUNTRY REPORT ON INFLATION

SELECTED ISSUES

July 2015

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CROSS-COUNTRY REPORT ON INFLATION

SELECTED ISSUES

June 22, 2015

Approved By
European Department

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APPENDICES

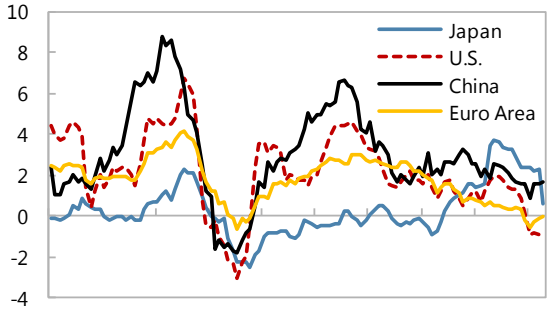
LOW INFLATION IN EUROPEAN INFLATION TARGETERS: CAUSES, SPILLOVERS, AND POLICY RESPONSES[1]

This paper takes a fresh look at the causes and drivers of low inflation in European inflation targeting countries outside the euro area, focusing on the Czech Republic, Poland, Sweden, and Switzerland. It estimates the effects on inflation from the output gap and external factors, including oil price changes, nominal effective exchange rate (NEER) fluctuations, and euro area inflation spillovers. The empirical model disentangles the contribution of direct and indirect first-round effects (e.g., through input-output linkages), as well as second-round effects working through inflation expectations. We find that external factors have been significant drivers of low inflation recently, though their contributions to inflation and the channels through which they operate vary across countries. Policy responses and options are discussed, taking into account country-specific circumstances.

A. Introduction

1. Global inflation is trending down. Amid modest global growth, headline inflation was persistently below 3 percent in G-7 countries, large parts of Europe, and China during 2013–14. As of April 2015, headline inflation in the United States (U.S.) and China had dropped markedly to -1.1 percent and 1.7 percent, respectively.

Headline Inflation in Major Economies
(Annual percent change)



Sources: Haver Analytics, national statistical agencies, and IMF staff calculations.

2. Inflation in the euro area is particularly low. This partly reflects still-sizable output gaps and debt overhangs weighing on growth. Overall, inflation in the euro area has steadily declined since late-2011 and stood at around zero percent in April 2015, following wide-spread disinflation, with 9 of 19 euro area countries experiencing deflation as of April 2015 (Figure 1).

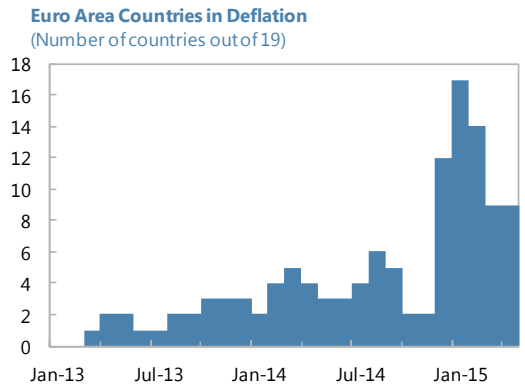
3. Surprisingly, inflation has also fallen to very low levels in many inflation-targeting countries outside the euro area. Low euro area inflation would be expected to spill over into countries pegged to the euro, which Iossifov and Podpiera (2014) show has been the case. However, in principle, inflation targeters should be able to counter disinflationary effects through monetary policy. Yet, inflation is also well below goal levels in a number of inflation targeting countries in the

[1] We would like to thank Costas Christou, Engin Dalgic, Kevin Fletcher, Davide Furceri, Plamen Iossifov, and Jiri Podpiera for their very useful comments and discussions.

region. This paper explores this puzzle, looking in particular at the Czech Republic, Poland, Sweden, and Switzerland, all of which recorded headline inflation near or below zero by the end of 2014.[2]

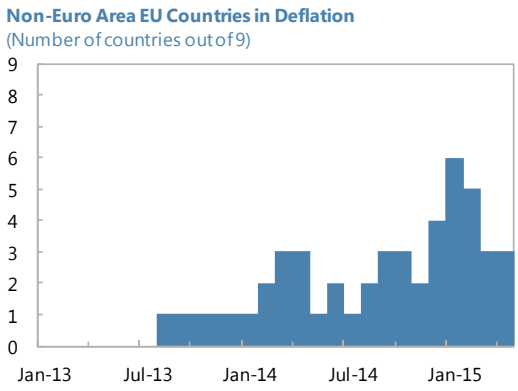
Figure 1. Disinflation in Europe

A number of countries are in deflation in the euro area…



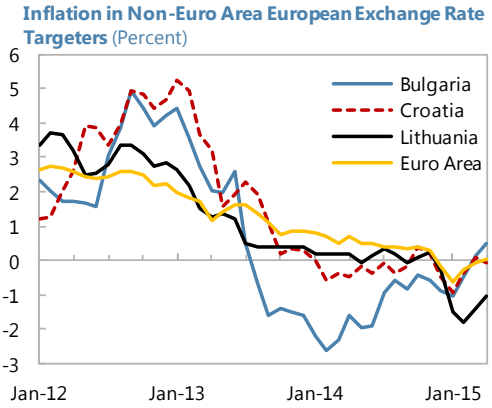
Sources: Eurostat and IMF staff calculations.

…as well as in other European Union (EU) countries.



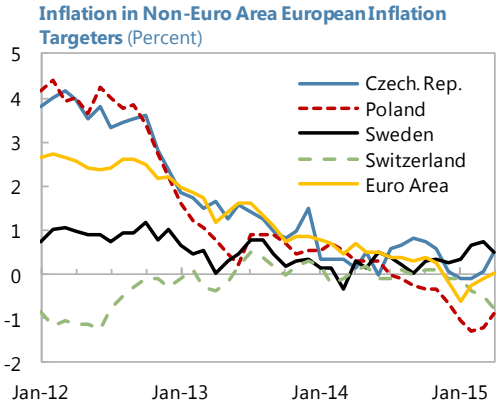
Sources: Eurostat and IMF staff calculations.

Countries with euro-pegs have imported disinflation…



Sources: Haver Analytics and IMF staff calculations.

…but inflation is also weak in inflation targeters.



Sources: Haver Analytics and IMF staff calculations.

4. Both domestic and external factors could be contributing to low inflation. Headline inflation can be broken down into core (headline excluding energy) and non-core inflation. Domestic factors (in particular the output gap) can affect core inflation, while external shocks—operating through multiple channels—can feed into both non-core and core components. For example, a change in the world price of oil can have *direct* first-round effects by impacting the non-core component of inflation through fuel prices. However, oil price changes can also have *indirect* first-round effects by feeding into core inflation through the input cost channel, such as through transportation costs and prices. Finally, both external and domestic factors can have *second-round* effects, with shocks impacting inflation expectations, which can affect price setting behavior.

[2] Inflation in Switzerland has been technically consistent with the Swiss National Bank's (SNB) definition of price stability, which is "less than 2 percent" inflation, and the SNB is not a formal inflation targeter. However, the SNB's annual reports state that deflation is to be avoided. Hence, in this paper, we assume that the SNB's de facto target range is 0–2 percent.

5. The analysis points to a prominent role for external factors. The results for the four countries of interest suggest that domestic output gap dynamics have had a relatively minor role in explaining recent inflation dynamics, whereas external factors, including oil price changes, exchange rate movements, and spillovers from low euro area inflation, have had a larger role. This has occurred not only through direct and indirect first-round effects on inflation, but also through second-round effects, which may be particularly concerning for monetary policy makers.

6. External shocks may result in a prolonged period of low inflation, which could become entrenched in inflation expectations. In a tail-risk scenario, unanchored inflation expectations could result in a downward spiral with increasing real debt burdens, declining corporate and bank profits, and worsening fiscal balances and debt. In turn, this highlights the importance of the central bank price stability mandate.

7. Faced with differing economic imbalances and available policy space, countries have implemented a variety of monetary policy actions to boost inflation. With policy rates near zero or negative, the Czech Republic and Switzerland turned to exchange rate intervention, while Sweden recently introduced quantitative easing (QE). Poland, with a policy interest rate at 1.5 percent, still has space for conventional easing even after substantial interest rate cuts over the last two years. However, while all the countries have taken measures to help boost inflation, they have so far been unsuccessful in putting inflation on a clear trajectory toward target. Even where fiscal space is available, fiscal policy has played a more limited role in the policy response so far. This reflects, among other things, the fact that unlike in the euro area, low inflation in these countries has occurred despite relatively robust economic activity (except in the Czech Republic, which experienced a recession during 2012–13).

8. The paper is organized as follows. We first describe the stylized facts, decomposing headline inflation into core and non-core components. We then present the analytical framework to assess the drivers of low inflation and subsequently present the results. Finally, we consider the specific country experiences and discuss the policy implications of our findings.

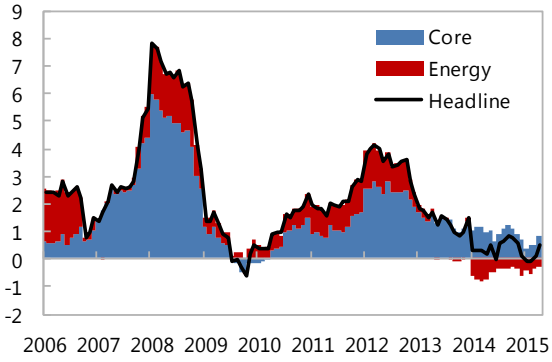
B. Drivers of Low Inflation: Stylized Facts

9. The drop in inflation has been broad-based. While some cross-country differences exist, both core and non-core disinflation has occurred across all of the inflation targeting countries in our sample (Figure 2). Core inflation's positive contribution to headline inflation has declined over the last few years in most of the countries and energy prices have contributed negatively to inflation for all of them.[3] In turn, external drivers appear a key source of disinflationary pressure. More specifically:

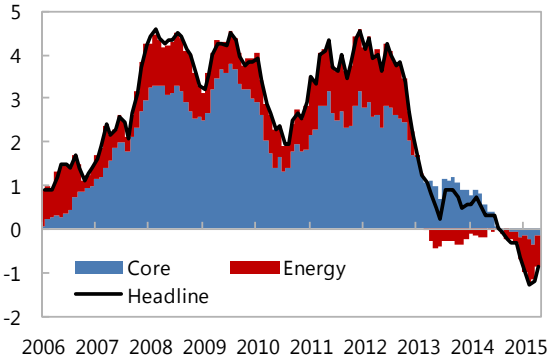
[3] Changes in indirect taxes and administered prices have also contributed to changes in our measure of core inflation in some countries.

- **Domestic drivers.** Domestic factors currently have a relatively small role in driving inflation.
  - ***Output gap.*** While the exact size of the output gap is subject to uncertainty, estimated output gaps nonetheless provide an important indicator of domestic drivers of inflation (see Appendix I). Specifically, output gaps currently remain negative in all four countries but, with the exception of the Czech Republic, are generally modest (Figure 3). In 2014, when disinflationary pressures picked up, all four countries experienced relatively robust growth, with output gaps closing fast. Nonetheless, robust domestic demand has so far failed to lift subdued core inflation in the face of headwinds from external factors.

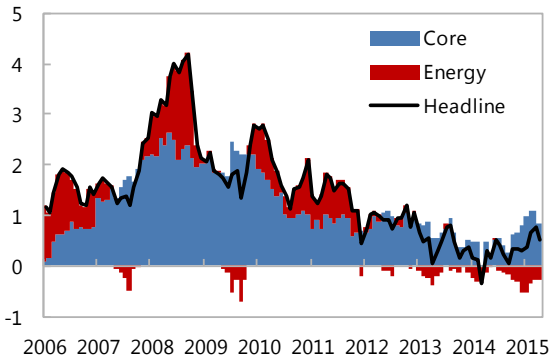
Figure 2. Decomposing Headline Inflation[1/]



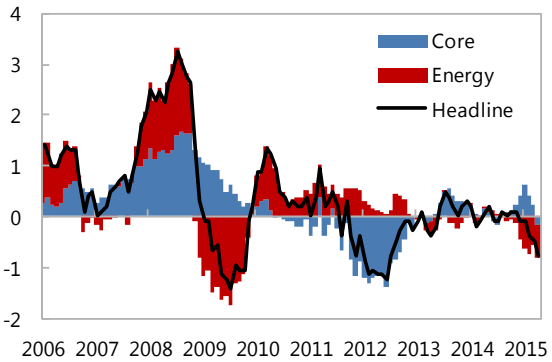
Sources: Eurostat and IMF staff calculations.



Sources: Eurostat and IMF staff calculations.



Sources: Eurostat and IMF staff calculations.



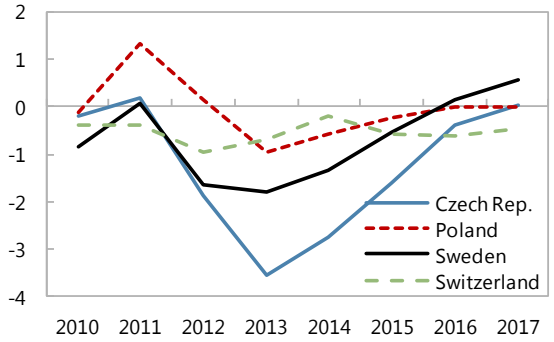
Sources: Eurostat and IMF staff calculations.

1/ Core inflation denotes inflation as measured based on the Harmonized Index of Consumer Prices (HICP), excluding energy prices.

Figure 3. Real Sector Activity

Output gaps are generally modest and set to narrow…

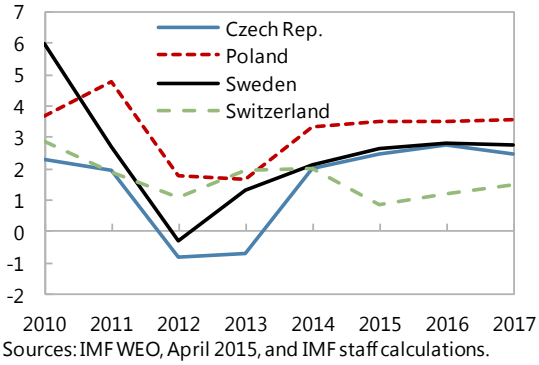
Output Gap
(Percent of potential GDP)



Sources: IMF World Economic Outlook (WEO), April 2015, and IMF staff calculations.

…amid robust growth in most of the countries.

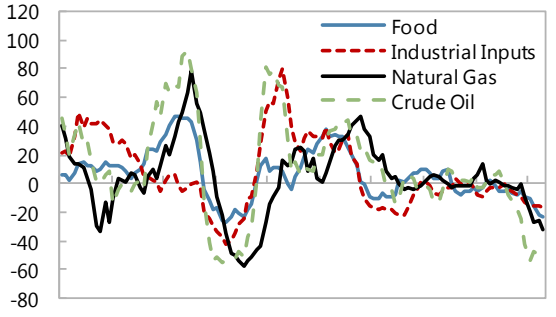
Real GDP Growth
(Percent)



Sources: IMF WEO, April 2015, and IMF staff calculations.

- **External drivers.** External factors have been a drag on inflation:
  - ***Oil prices.*** Oil price declines have been an important driver of domestic non-core energy price inflation. While commodity prices were fairly stable during most of 2013, they declined substantially in the second half of 2014. Most notably, oil prices dropped more than 50 percent between mid-2014 and January 2015, contributing to lower inflation globally and in Europe.

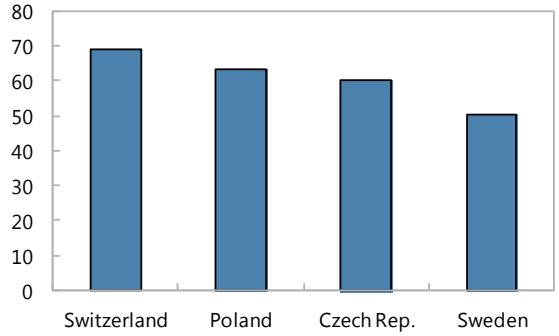
Commodity Prices
(Annual percent change)



Sources: IMF International Financial Statistics and IMF staff calculations.

  - ***Spillovers from the euro area.*** These can play a crucial role as well, given tight trade linkages. Disinflation in the euro area could be directly imported, as around 60 percent of imports are from the euro area, with a high share of euro area value added finally consumed domestically. In addition, low growth and the relatively large output gap in the euro area, which stood at close to 3 percent in 2014, has contributed to weak external demand.

Imports from Euro Area, 2014
(Percent of total imports)

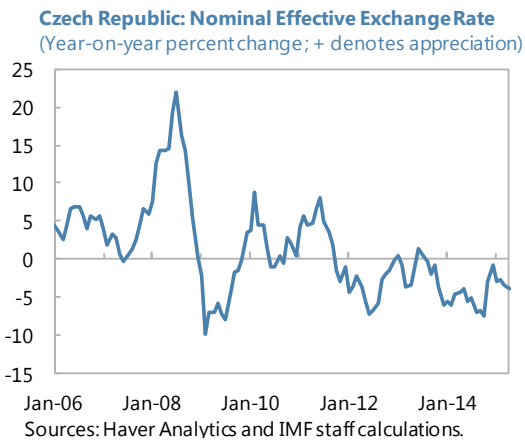


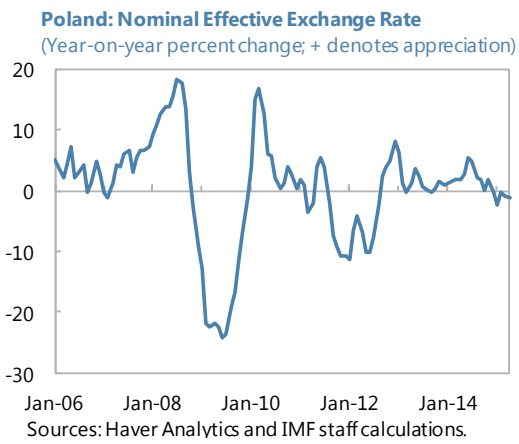
Sources: IMF Direction of Trade Statistics and IMF staff calculations.

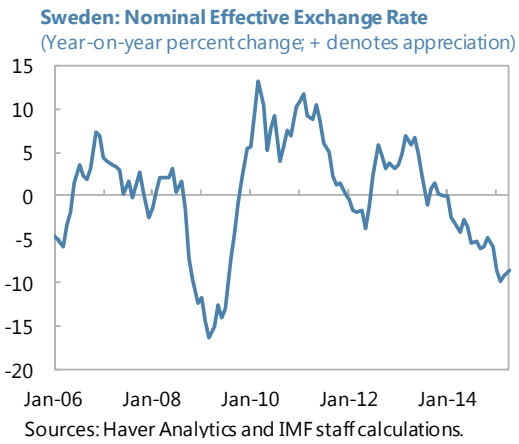
  - ***NEER.*** Sustained periods of NEER appreciation can damp imported inflation. This is particularly relevant for Sweden and, even more so, Switzerland, which has seen significant net capital inflows, including recently related to QE in the euro area and

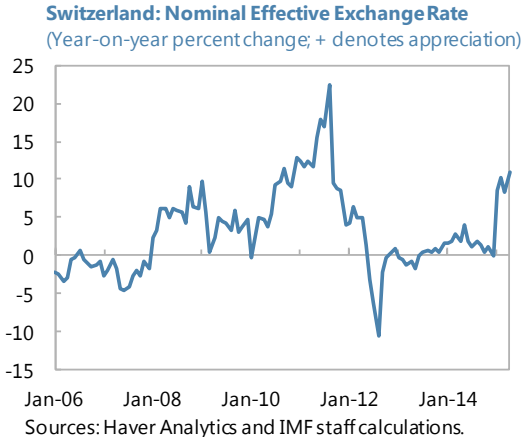
other factors (Figure 4). Conversely, NEER depreciation in the Czech Republic, starting in late-2013, has helped lift imported inflation. The NEER can be affected by both domestic (related to monetary policy actions) and external (related to global shocks) factors. We group the NEER with external drivers of inflation to highlight that external shocks (e.g., "safe-haven" capital flows during the euro area crisis) were important contributors to exchange rate fluctuations in the four small open economies we study, particularly in recent years.

Figure 4. Nominal Effective Exchange Rates

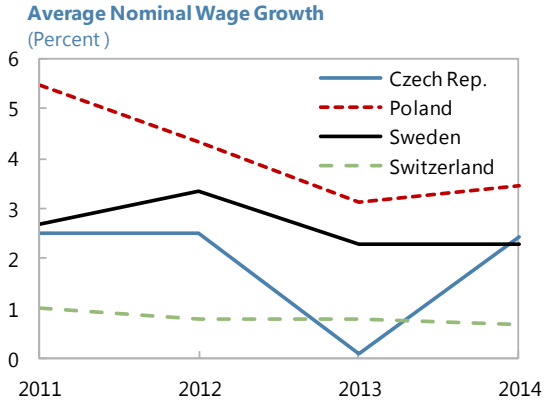








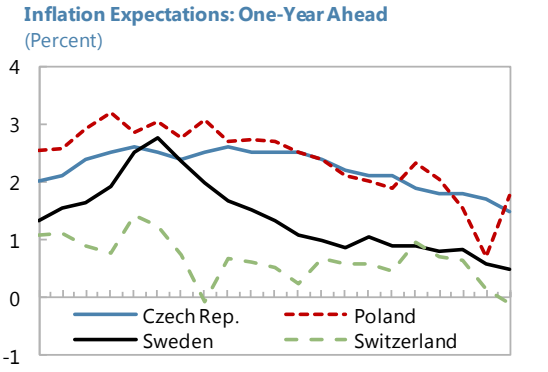
10. Disinflationary pressure from external factors has been increasingly feeding into inflation expectations. Evidence of second-round effects of low inflation is appearing in expectations. One-year ahead expectations may be expected to decline as disinflation complicates a quick return to target. More concerning, however, is the downward trend in longer-term expectations (Figure 5). Two-year ahead inflation expectations have been particularly weak in Sweden and Switzerland. Longer-term expectations in Poland and the Czech Republic have also been on a downward trend, while remaining broadly around the target. Despite declining expectations, nominal wage growth generally held up well in 2014 (though in Switzerland it has been low for some time), although slightly down from growth rates during 2011 when output gaps were last closed.



Sources: IMF International Financial Statistics and IMF staff calculations.

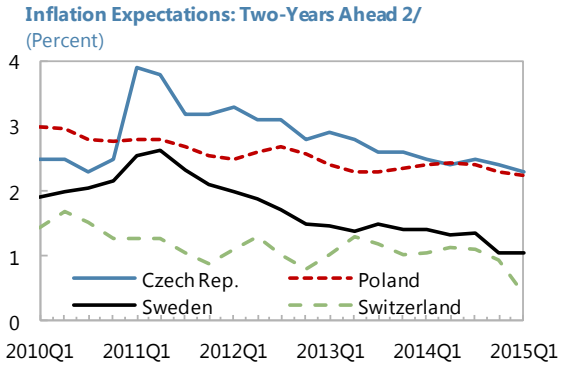
Figure 5. Inflation Expectations[1/]

Deflation has led to a drop in near-term expectations...



Sources: Consensus Economist, TNS Prospera, Czech National Bank, and IMF staff calculations.

...but two-year ahead expectations are also trending down.



Sources: Consensus Economist, TNS Prospera, Czech National Bank, and IMF staff calculations.
2/ 3-year ahead expectations for the Czech Republic.

[1/] Current inflation targets for the four countreis are as follows: Czech Republic 2 percent ± 1 percentage point; Poland 2.5 percent ± 1 percentage point; Sweden: 2 percent; Switzerland: below 2 percent.

C. A More Structured Approach

The analytical framework

11. Understanding the drivers of inflation is important for calibrating the policy response. In principle, policy makers can "look through" exogenous supply shocks that have only temporary effects and allow these to work their way through headline inflation. However, protracted inflation shocks could impact inflation expectations, opening the door to significant second-round effects on inflation. This raises concerns about unanchored inflation expectations damaging the credibility of the inflation targeting monetary policy regime. Further complications arise since, in practice, it is

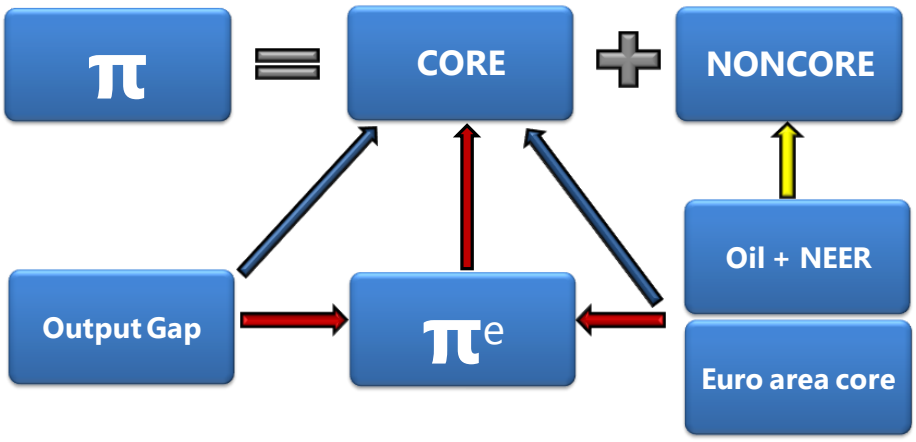
difficult to disentangle temporary from protracted shocks, complicating monetary policy. In addition, monetary policy in the euro area will have spillovers through its effect on euro area inflation and on capital flows. For small open economies such as the four we examine here, ample liquidity in the context of European Central Bank (ECB) QE could result in exchange rate appreciation pressures, creating a drag on inflation. A number of factors need to be taken into consideration for fiscal policy too, including fiscal space, monetary policy constraints, and domestic and external balances.

12. The literature offers a number of approaches. A number of papers have aimed at understanding the main drivers of consumer price inflation (see, for example, Gali and Gertler (1999)). Some studies have explored the importance of exchange rate changes (Burstein and Gopinath, 2014). Others have focused more explicitly on the importance of the monetary policy regime (Gali and Monacelli, 2005). In light of the recent drop in inflation across a number of countries, the importance of other external factors has become increasingly relevant. Iossifov and Podpiera (2014) found in a panel setting that in addition to falling commodity prices, recent low euro area core inflation has spilled over to non-euro area EU countries. Both Mija and others (2013) and IMF (2015a) highlight signs of second-round effects on inflation.

13. A more structured approach can contribute to further disentangle the various domestic and external factors driving inflation. While the decomposition of headline inflation in Section B above suggests that external factors are important drivers of declining core and noncore inflation, the channels through which this occurs remain to be examined. Our analytical approach differentiates between domestic and external factors. This is particularly important in light of the recent flattening of the traditional Phillips curve, pointing to a smaller role of output gaps in inflation fluctuations (see for example IMF, 2013 and 2015b). In addition, we distinguish direct and indirect first-round effects of the external factors from their second-round effects (Figure 6). Separate equations for core and non-core inflation, as well as inflation expectations, allows us to trace the effects of shocks to oil prices, the NEER, and euro area core inflation through the system.[4] Appendix II provides a detailed discussion of the model and its empirical specification that is applied on a country-by-country basis for sample periods ranging between 12 and 17 years. The approach is designed to minimize endogeneity issues and facilitates the analysis of global oil price shocks that tend to impact our sample economies directly, but also through shocks' (indirect) impact on euro area core inflation.

[4] In the econometric analysis, we define core inflation as headline inflation, excluding energy price inflation. Using other definitions to explicitly account for food price inflation did not materially alter the results.

Figure 6. System of Equations[1]



1/ Yellow arrow denotes direct first-round efffects of oil price and NEER fluctuations; blue arrows denote indirect first-round effects of domestic and external factors; and red arrows denote second-round effects of domestic and external factors.

Empirical results

14. The empirical results suggest that external factors are indeed significant drivers of inflation.[5] Historical decompositions using this approach attribute inflation developments to both domestic and external factors, but with external factors accounting for the largest contribution (Figure 7).

- **Domestic factors.** The output gap has impacted inflation in all four countries, though overall its impact has typically been relatively small.[6] In particular, in the run-up to the global financial crisis, positive output gaps put upward pressure on inflation. More recently, the output gap has been a dampening factor, reducing inflation by around half a percentage points in all countries, except Switzerland. In addition, for the Czech Republic and Poland, we account for changes in administered prices, which have tended to raise inflation. In the case of the Czech Republic, we also account for the effect of tax changes (indirect and excise taxes mainly), which have contributed positively to inflation.

- **External drivers.** Oil price changes, euro area core inflation, and NEER fluctuations have generally had a larger combined impact than the output gap—with oil price changes generally a major contributor. Spillovers from falling euro area core inflation have also weighed on domestic

[5] See Appendix II for detailed regression results. Also, note that while the model provides a relatively good fit for each of the countries, the "other" categories in Figure 7 collects otherwise unaccounted for domestic and external shocks to inflation and their persistent impacts.

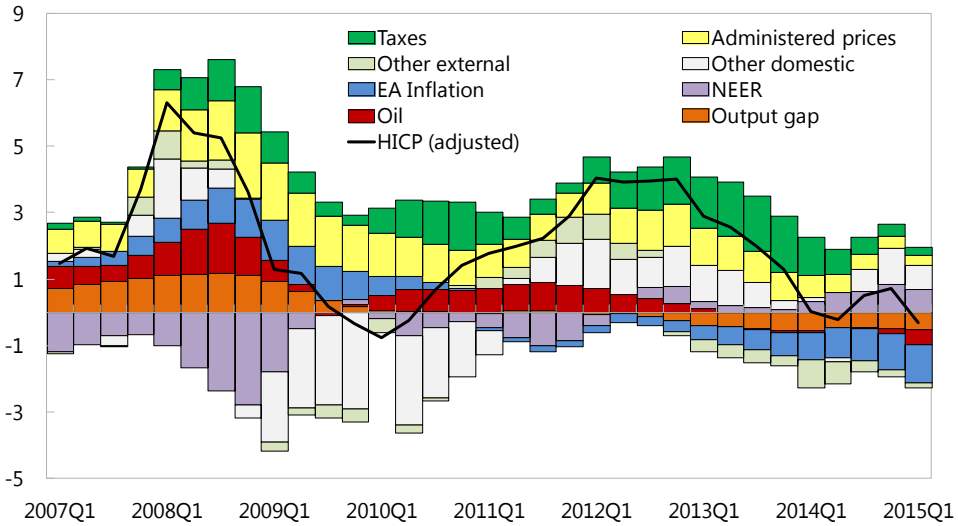
[6] A zero output gap does not imply that inflation would be zero. For example, in a simple New Keynesian model, inflation would converge to its steady-state level, reflecting, among other things, the central bank's inflation target. Note that Figure 7 shows the decomposition of HICP, adjusted for the constants in the regression framework.

inflation during 2013–14, particularly in the Czech Republic, Poland, and Switzerland. For Sweden and Switzerland, NEER appreciations had sizable negative effects on inflation during the last few years. In contrast, exchange rate intervention and the introduction of an exchange rate floor against the euro in the Czech Republic in late 2013 boosted inflation over the past year (see country case experiences below).

Figure 7. Decomposition of Contributions to Inflation

Czech Republic

(Percentage point contributions)

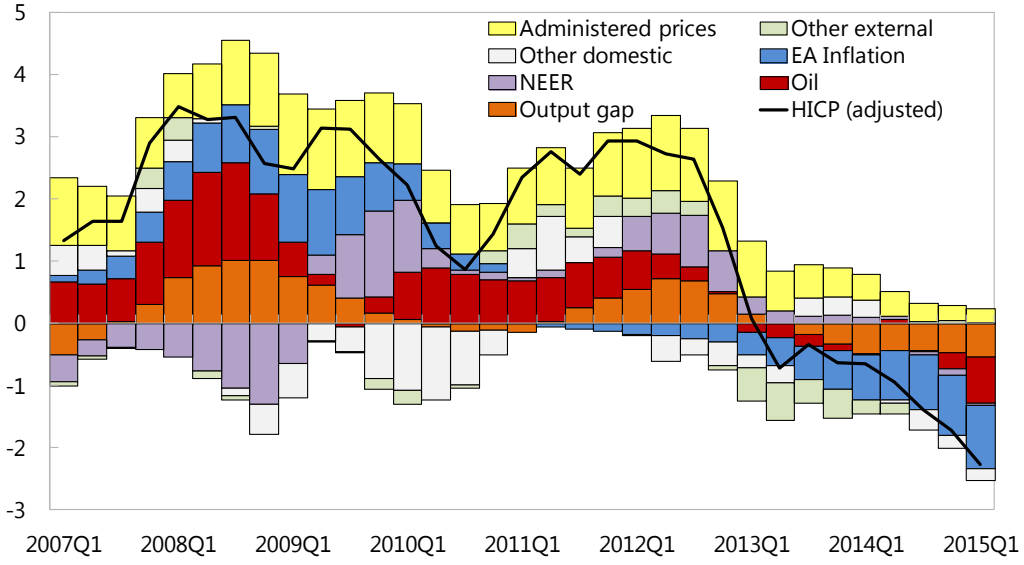


Sources: Czech National Bank, Consensus Forecasts, Eurostat, Haver Analytics, IMF World Economic Outlook (WEO), and Fund staff calculations.
Note: HICP inflation is adjusted to account for the constants in the regression framework and any insignificant external factors (see Appendix II). "Other domestic" are the residuals and base effects from the core and expectations equations, while "Other external" are the base effects and residuals from the non-core inflation equation.

Figure 7. Decomposition of Contributions to Inflation (continued)

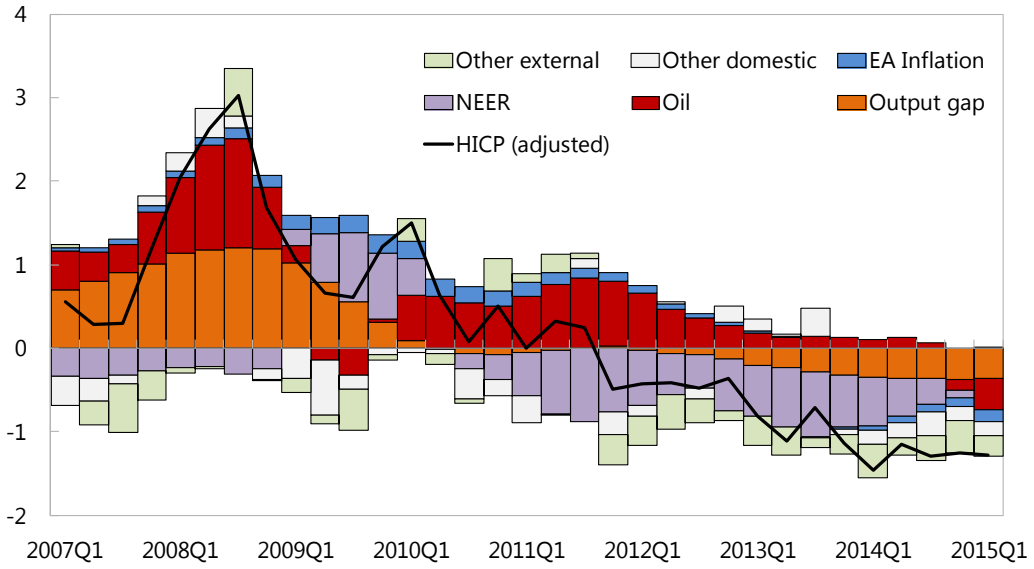
Poland

(Percentage point contributions)



Sweden

(Percentage point contributions)

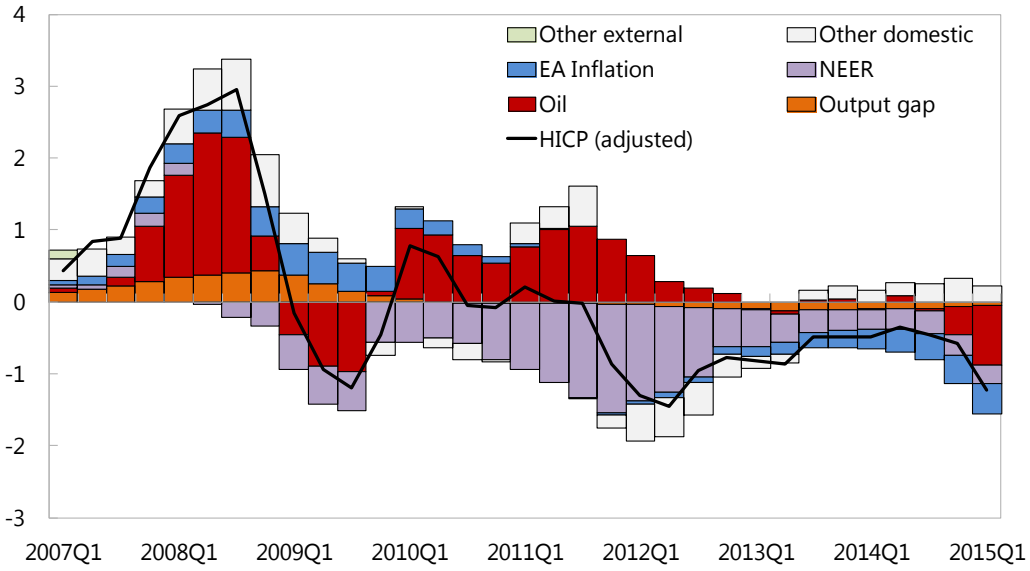


Sources: Consensus Forecasts, Eurostat, Haver Analytics, IMF WEO, Sveriges Riksbank, and Fund staff calculations.
Note: HICP inflation is adjusted to account for the constants in the regression framework and any insignificant external factors (see Appendix II). "Other domestic" are the residuals and base effects from the core and expectations equations, while "Other external" are the base effects and residuals from the non-core inflation equation.

Figure 7. Decomposition of Contributions to Inflation (concluded)

Switzerland

(Percentage point contributions)



Sources: Consensus Forecasts, Eurostat, Haver Analytics, IMF WEO, and Fund staff calculations.
Note: HICP inflation is adjusted to account for the constants in the regression framework and any insignificant external factors (see Appendix II). "Other domestic" are the residuals and base effects from the core and expectations equations, while "Other external" are the base effects and residuals from the non-core inflation equation.

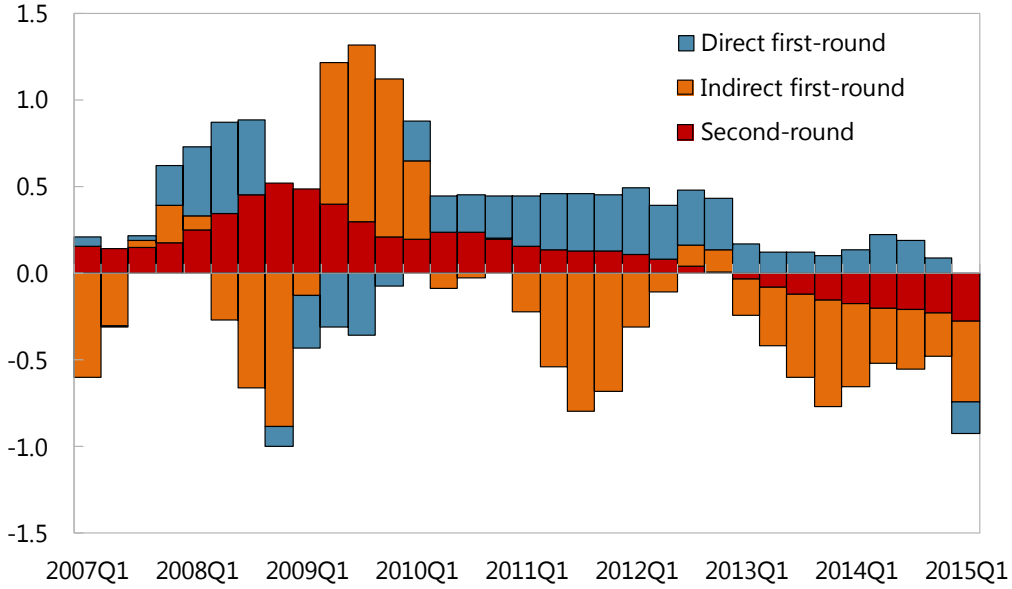
15. Indirect and second-round effects have been material. The model also allows us to decompose the sum of the impacts of external shocks on headline inflation into direct first-round effects, affecting headline inflation through non-core inflation; indirect first-round effects, affecting headline inflation through core inflation;[7] and second-round effects, affecting core inflation through inflation expectations (Figure 8). Across all four countries, direct first-round effects (blue bars) from external factors are similar in terms of direction and timing, largely corresponding to oil price fluctuations. However, external factors typically have the largest impact through indirect first-round effects (orange bars). Second-round effects (red bars) tend to be smaller, but are non-negligible in most cases. In particular, while the contribution of second-round effects to inflation has been positive in the past, it has recently declined in most of the countries, turning negative in the Czech Republic and Sweden.

[7] While imported final goods in the core inflation basket would also have a direct effect, we do not disentangle this effect from the effect of shocks that have indirect effects, such as oil price inflation affecting transportation costs.

Figure 8. First-Round and Second-Round Effects of External Factors

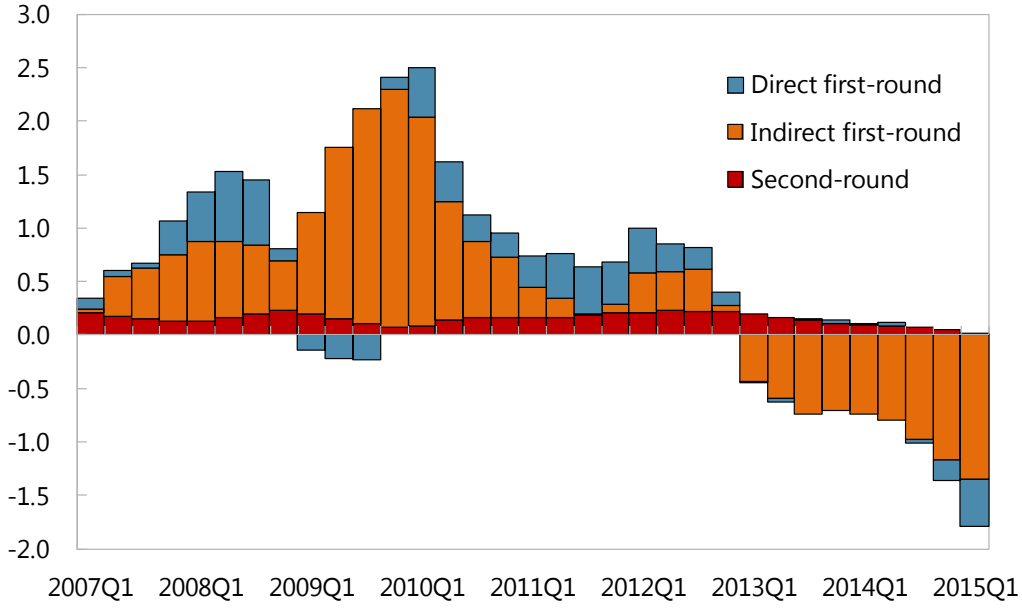
Czech Republic

(Percentage point contributions)



Poland

(Percentage point contributions)

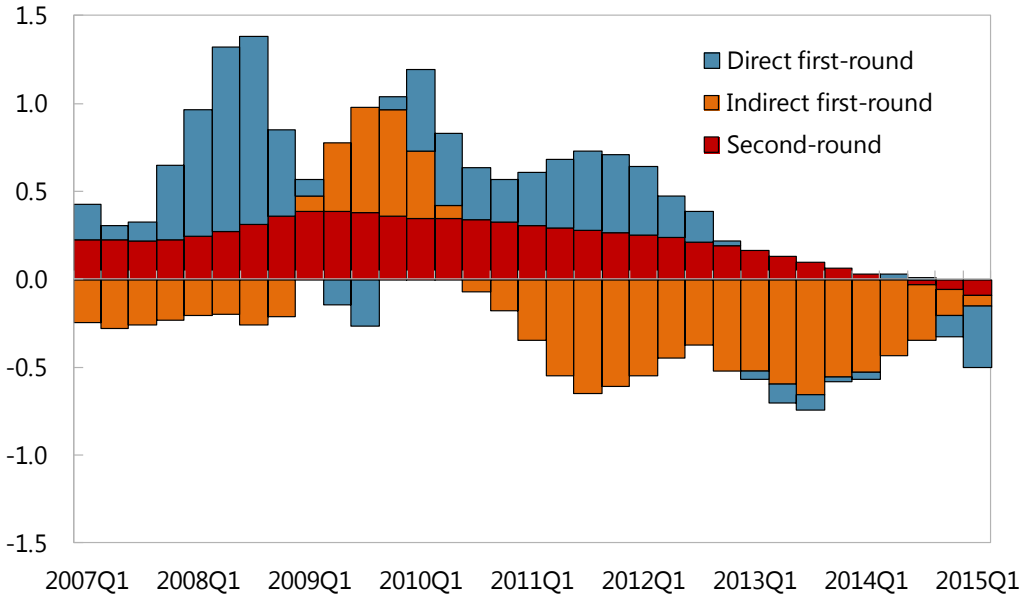


Sources: Czech National Bank, Consensus Forecasts, Eurostat, Haver Analytics, IMF WEO, and Fund staff calculations.
Note: The direct and indirect first-round effects and second-round effects of all three external factors (i.e., oil price changes, euro area core inflation, and NEER fluctuations) are summed to get the aggregate contribution of external factors through each effect.

Figure 8. First-Round and Second-Round Effects of External Factors (concluded)

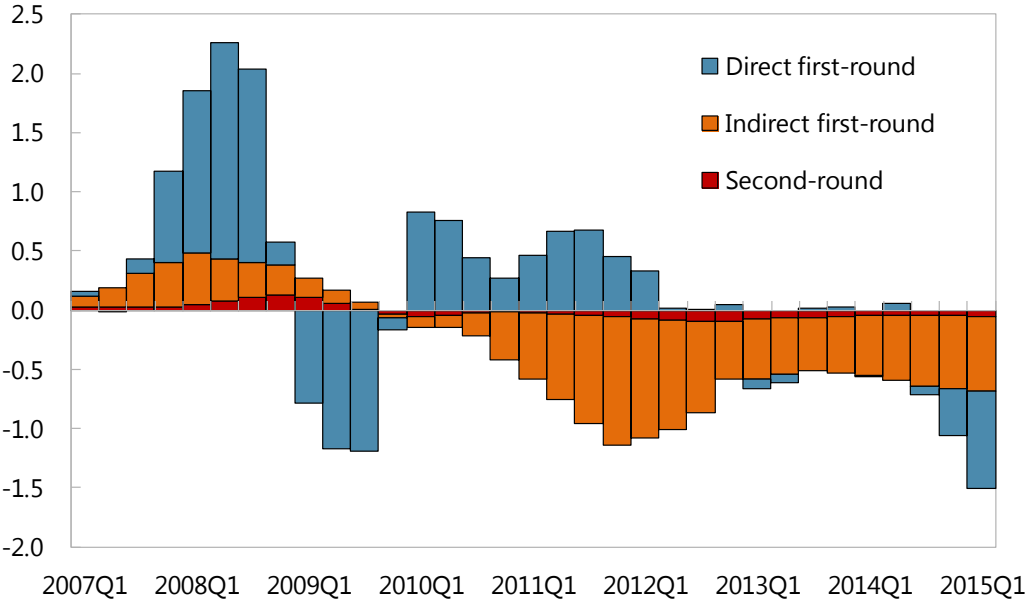
Sweden

(Percentage point contributions)



Switzerland

(Percentage point contributions)



Sources: Consensus Forecasts, Eurostat, Haver Analytics, IMF WEO, Sveriges Riksbank, and Fund staff calculations.
Note: The direct and indirect first-round effects and second-round effects of all three external factors (i.e., oil price changes, euro area core inflation, and NEER fluctuations) are summed to get the aggregate contribution of external factors through each effect.

16. The effects of external shocks can be sizable and persistent. Moving beyond historical decompositions, the model can also be used to illustrate how future shocks to external factors would impact headline inflation. In addition to informing policymakers about what could be, this exercise is also helpful to understand the degree of persistence of shocks' effects on inflation. Indeed, the impulse responses of inflation to external shocks illustrate that even short-lasting shocks may continue to impact headline inflation for several years (Figure 9).

- **Oil price shock.** The first panel in Figure 9 illustrates the impact of a 10 percentage point drop in the oil price in period 1. For all four countries, the peak impact occurs at the time of the shock, though the size of the impact differs across countries, with the Czech Republic and Switzerland experiencing the largest impact. The impact of the shock fades relatively quickly, diminishing to half its initial size after 1 to 3 quarters.

- **Euro area core inflation shock.** We construct the euro area core inflation shock as a -0.5 percentage point persistent shock. That is, euro area core inflation does not revert immediately back to the baseline in the following quarter.[8] Thus, a euro area core inflation shock has a very persistent impact on inflation in all four countries. The impact is largest in the Czech Republic and Poland, with the effect of the shock peaking at around -0.3 to -0.4 percentage points after 5 quarters. This is consistent with these countries' close integration with the euro area (in particular Germany). In Switzerland the impact is smaller, around -0.15 percentage points, and peaks after 6 quarters. Sweden experiences the smallest impact from the shock, peaking at -0.07 percentage points, but is particularly persistent with the peak occurring after 12 quarters.

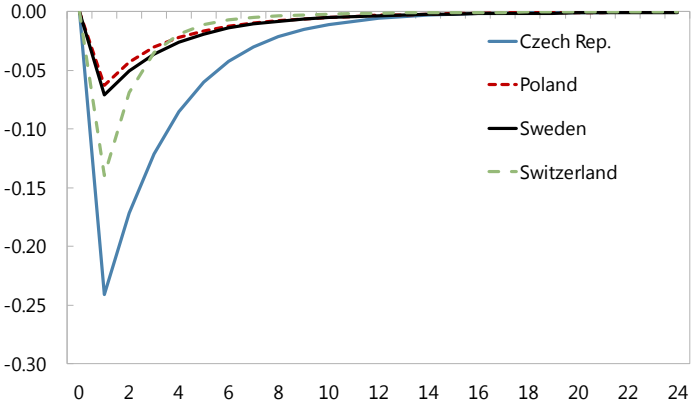
- **NEER shock.** The third panel in Figure 9 shows the impulse responses to a 5 percentage point appreciation in the NEER in period 1. As with the oil shock, the peak impact occurs in the quarter of the shock but the effect is more persistent. It generally takes 3 to 5 quarters for the effect to decline to half its initial impact. Inflation in the Czech Republic is the most responsive to the NEER shock, falling more than 0.4 percentage points at peak, whereas the peak impact reaches around -0.2 percentage points in the other countries. The Czech Republic's responsiveness to a NEER shock is likely due to imports accounting for a substantial share of consumption.

17. Second-round effects can have long-lasting impacts. The model also allows us to examine the impact on headline inflation of a shock to inflation expectations no matter its source. The peak impact of a 1 percentage point negative shock to inflation expectations varies across countries. The largest peak responses occur for Poland and Switzerland (Figure 10). However, in all cases the impact is relatively persistent (though less so for the Czech Republic and more so for Sweden), with inflation still below the baseline after 12 quarters. In turn, these sizable and persistent effects emphasize the importance of well-anchored inflation expectations and that monetary policymakers should be vigilant that shocks' effects do not become entrenched in expectations.

[8] The euro area shock decays over time according to the coefficient on the lagged euro area core inflation in the euro area core equation described in Appendix II (equation (7)).

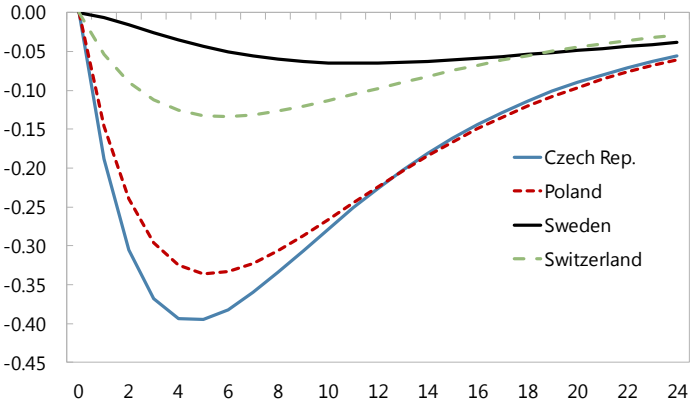
Figure 9. Inflation Responses to External Shocks

Inflation Responses to Oil Shock
(Percentage points)



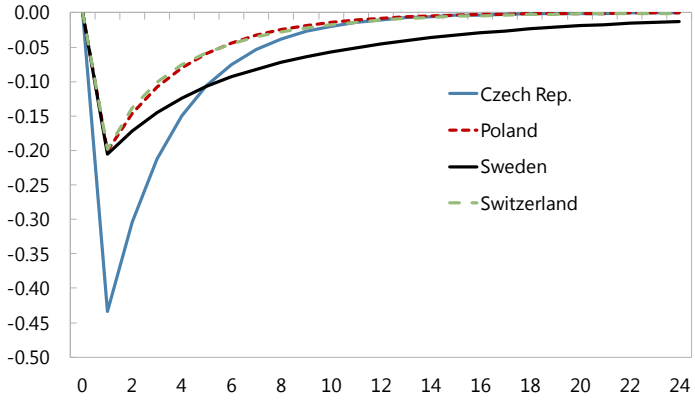
Note: Impulse response of headline inflation to a -10 percentage point drop in oil price inflation in quarter t=1.

Inflation Responses to Euro Area Core Inflation Shock
(Percentage points)



Note: Impulse response of headline inflation to -0.5 percentage point drop in euro area core inflation in quarter t=1.

Inflation Responses to NEER Shock
(Percentage points)

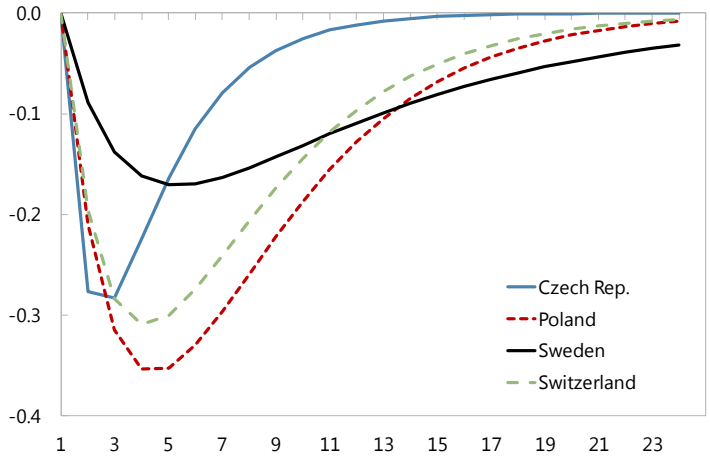


Note: Impulse response of headline inflation to a 5 percentage point NEER appreciation in quarter t=1.

Source: IMF staff calculations.

Figure 10. Inflation Responses to Inflation Expectation Shock[1/]

(Percentage points)



Source: IMF staff calculations.

1/ Impulse response from a 1 percentage point drop in inflation expectations.

Box 1. Poland: Disaggregate Model to Assess Indirect and Second-Round Effects

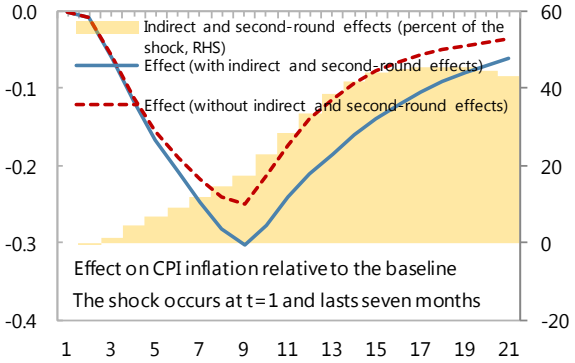
A disaggregate model of inflation serves as a robustness check for assessing combined indirect and second-round effects. The disaggregate model follows the setup in Leon (2012) and Christiansen and Ebeke (2015) and takes into account the granular information contained in the subcomponents forming the consumer price index (CPI). In particular, it allows domestic and external shocks to affect producer prices and, subsequently, feed into a number of components of headline CPI, which interact with each other. In turn, combined first-round indirect and second-round effects are captured as the difference between the full effect of shocks on CPI inflation and the portion of the CPI inflation response, which excludes feedback effects between components of CPI. The details of the model are described in Christiansen and Ebeke (2015).

The disaggregate model points to significant indirect and second-round effects in Poland.

- **Commodity price shock.** About 20 percent of the effect from a cumulative 63 percentage points decline in oil and coal price inflation over 7 months is accounted for by indirect and second-round effects. These are persistent, representing more than 40 percent of the impact on CPI inflation after 18 months.
- **Euro area inflation shock.** After 9 months, about 20 percent of a protracted cumulative 2 percentage points decline in euro area inflation (lasting a total of 18 months) is accounted for by indirect and second-round effects. After 18 months, these effects account for more than 25 percent of the change in CPI inflation.

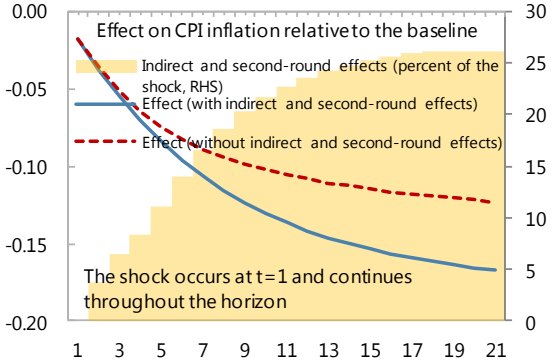
These results are in line with the main results in this paper. Consistent with the results using the Seemingly Unrelated Regressions (SUR) approach, the combined effects of indirect first-round and second-round effects can be substantial and have persistent effects on headline inflation. The recently observed declines in oil prices as well as protracted disinflation in the euro area would therefore likely continue to affect headline inflation for months to come.

Effect on CPI Inflation of Protracted 9 Percentage Point Decline in Oil and Coal Price Inflation (Percentage points)



Source: IMF staff calculations.

Effect on CPI Inflation of Protracted 0.1 Percentage Point Decline in Euro Area Inflation (Percentage points)

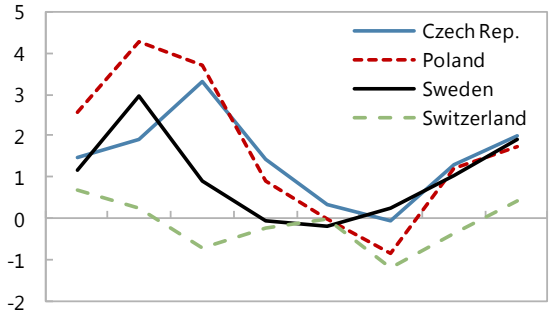


Source: IMF staff calculations.

D. The Policy Response to Inflation so Far

18. While policy responses have differed, all countries took monetary measures to boost inflation. Policymakers are generally concerned about guiding inflation back to target to avoid inflation expectations becoming unanchored. While Poland has monetary policy space to continue conventional monetary easing, the other countries face more constraints. After running out of conventional monetary policy space, Sweden pushed its policy rate into negative territory and initiated a QE program. In contrast, given concerns about the effectiveness of QE in the Czech Republic and Switzerland, unconventional measures involving the foreign exchange market were implemented after policy rates hit the zero lower bound. Common to all of them, however, is that headline inflation is projected to remain low for a prolonged period. In what follows, we discuss in more detail the countries' experiences so far.

Inflation Projections
(Percent)

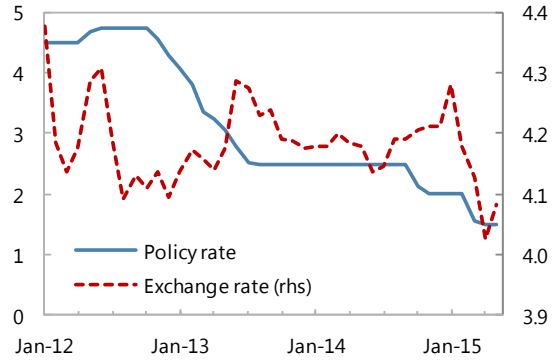


Sources: IMF WEO, April 2015, and IMF staff calculations.

Poland: Conventional monetary policy space available

19. Substantial monetary policy easing helped reinvigorate growth but disinflation continued. Along with weakening growth in 2012, declining inflation led to cumulative rate cuts of 225 basis points to 2.5 percent between November 2012 and July 2013. Subsequently, growth strengthened to 3.4 percent in 2014. However, inflation continued to diverge from its target (2.5 percent ±1 percentage point), turning into deflation in July 2014. A second round of monetary easing was implemented, with the policy rate declining to 1.5 percent in March 2015. At the same time, and despite weak inflation expectations and an appreciating zloty, the Monetary Policy Council announced the end of the easing cycle. Paying due attention to growth, gradual fiscal consolidation in 2014 was geared toward putting the deficit on a path to exit the EU's Excessive Deficit Procedure. Alongside, macroprudential policies have been gradually strengthened, including by lowering loan-to-value (LTV) limits, and work is underway to establish a formal macroprudential body.

Poland: Policy Rate and Exchange Rate
(LFS: Percent ; RHS: zloty per euro, zloty depreciation=+)



Sources: Haver Analytics and IMF staff calculations.

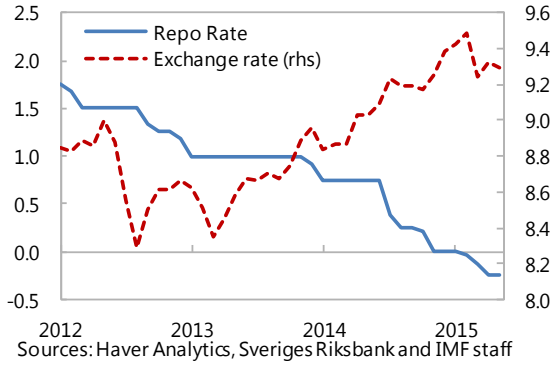
Sweden: Turning to QE

20. With inflation falling and below target, Swedish monetary policy turned increasingly expansionary despite concerns about macro-financial stability risks. In a number of steps, the Riksbank reduced its policy rate starting in December 2011 and provided forward guidance by

lowering the repo rate forecast on several occasions. In mid-2014, with headline deflation and medium-term inflation expectations drifting below the 2 percent target, it accelerated its cuts, reaching the zero lower bound in October 2014. This came despite continued concerns about high household debt and strong house price growth. These have continued rising despite the introduction of several macroprudential policy measures, including an LTV ratio cap and minimum risk weights on mortgages. Fiscal policy remained mildly expansionary throughout this period.

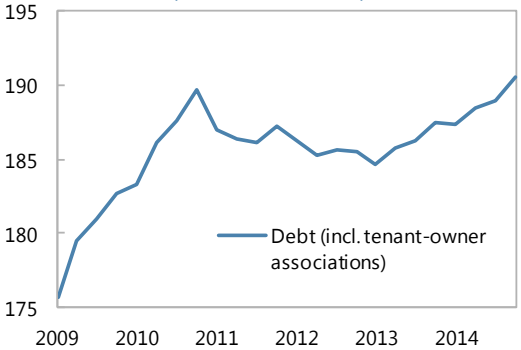
21. Recently, the Riksbank has cut the policy rate below zero and engaged in domestic QE. By March 2015, it had reduced the policy rate to -0.25 percent. The QE program, first introduced at a small scale, has since been increased to about 80–90 billion Swedish kronor, equivalent to the expected issuance of krona-denominated central government bonds in 2015. In addition, the Riksbank has communicated that it has a range of further policy options, noting that foreign exchange (FX) interventions could be part of its policy toolkit should other domestic measures not succeed in lifting inflation. The initial evidence suggests that QE has been successful in impacting interest rates across maturities, broadly in line with the experiences in other countries that have conducted QE programs. Longer-term inflation expectations have begun to reverse their decline, rising closer to the 2 percent inflation target in March. The impact on the exchange rate has been more limited. After strengthening as the ECB announced and then implemented QE in the euro area, the krona/euro rate weakened slightly in reaction to the Riksbank's most recent expansionary moves.

Sweden: Policy Rate and Exchange Rate
(LHS: Percent; RHS: krona per euro, depreciation=+)



Sources: Haver Analytics, Sveriges Riksbank and IMF staff calculations.

Sweden: Household Indebtedness
(Percent of disposable income, end point=2014Q4)

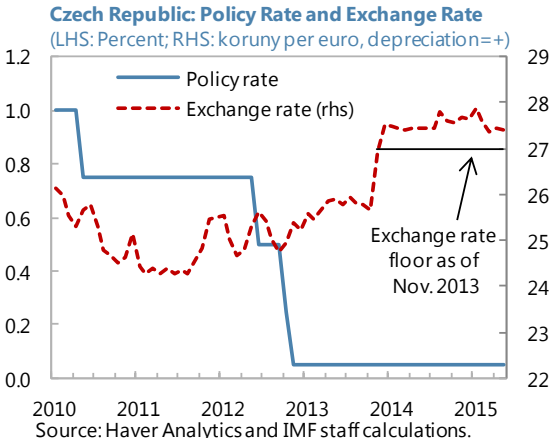


Sources: SEB, Sveriges Riksbank, Statistics Sweden, and IMF staff calculations.

Czech Republic: One-time exchange rate intervention and exchange rate floor

22. Low inflation first prompted conventional monetary easing. Amid declining inflation, limited signs of asset price bubbles, and strengthening net capital inflows, a monetary policy easing cycle started in mid-2012. Through three interest rate cuts, the policy rate reached a low of 0.05 percent before the end of the year. However, disinflation continued, and inflation has been below the lower end of the target band (2 percent ±1 percentage point) throughout 2014. Nonetheless, three-year ahead inflation expectations remain well anchored at above 2 percent.

23. Further attempts to lift inflation consisted of more unconventional measures. With the main policy rate near zero, the authorities faced limited room for further interest rate cuts. In addition, they assessed that already low long-term rates and a liquid banking system would likely render QE using domestic assets ineffective. Instead, the Czech Republic, as a small open economy, would be expected to experience significant pass-through to inflation from a depreciation of the exchange rate. An exchange rate floor at 27 koruny per euro was implemented in November 2013, backed by foreign exchange intervention, which led to a 6 percent depreciation of the koruna, to help lift inflation. Financial markets promptly internalized the change, and the exchange rate remained at a depreciated level slightly beyond what was warranted by the floor, despite no further interventions in the foreign exchange market. The fiscal stance was also relaxed by about 1 percent of GDP in 2014, likely contributing to the pick-up in growth. In addition, the macroprudential framework was strengthened, including by elevating financial stability to a policy objective in the Czech National Bank law and through regular meetings on financial stability.

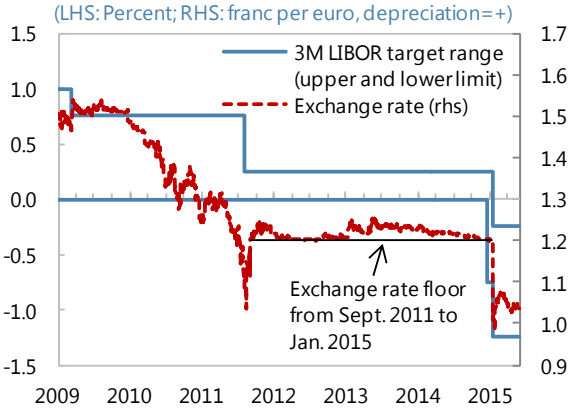


24. These unconventional measures showed initial signs of success. The exchange rate depreciation had the expected pass-through to tradables prices, which helped support inflation. Year-on-year inflation in the fall of 2014 climbed to 0.7 percent, just marginally below the lower end of the inflation tolerance band. However, the sharp decline in oil prices during the second half of 2014 and declining euro area core inflation has fed through to headline inflation, pulling inflation back to around zero.

Switzerland: Substantial exchange rate interventions before exiting from the floor

25. To limit franc appreciation and its impact on inflation, an exchange rate floor was introduced. During the first three quarters of 2011, strong capital inflows resulted in a substantial appreciation of the Swiss franc (CHF) against the euro and lowered imported inflation. Notwithstanding concerns about risks related to rising house prices and household debt, the SNB cut its policy rate to zero in 2011 to stem appreciation pressures and help lift imported inflation. However, as appreciation continued, a floor of CHF1.20 per euro was implemented in September 2011. Though headline inflation was still close to or below zero after the floor was introduced, the decomposition in Figure 7 suggests inflation probably would have been even lower in the absence of the exchange rate floor.

Switzerland: Interest Rate Range and Exchange Rate
(LHS: Percent; RHS: franc per euro, depreciation=+)



Sources: Bloomberg and IMF staff calculations.

Switzerland: Household Debt
(Percent of gross disposable income)

Sources: Swiss National Bank and Haver Analytics.

26. However, faced with increasing divergences between monetary policies of major currency areas, the SNB concluded that the exchange rate floor was no longer sustainable. While the floor was effective in stemming further appreciation, substantial exchange rate pressure in late 2014 prompted renewed interventions at a rapid pace. As a result, the size of the SNB's balance sheet expanded substantially, approaching 90 percent of GDP. In addition, the SNB was concerned that, once the magnitude of its interventions became public, speculation about exit from the floor would mount, fueling a vicious cycle of rising inflows and a rapidly growing balance sheet (IMF, 2015c). In turn, the SNB made a surprise move to exit from the exchange rate floor on January 15, 2015 and lowered the deposit rate to -0.75 percent.[9] Even as rates have moved into negative territory, macroprudential policies introduced over the last few years to limit housing-related risks, including minimum down payment and amortization requirements, appear to be having some effect. Meanwhile, Switzerland's fiscal rule has helped it maintain low deficits and debt, requiring the federal government budget to be in structural balance *ex ante* and that any *ex post* overruns be made up by running structural surpluses.

27. The exit from the exchange rate floor led to a sharp appreciation, with potentially adverse effects on growth and inflation. By April 2015, the real effective exchange rate (REER) had appreciated by about 10 percent relative to its average level in 2014. The appreciated level of the exchange rate could result in new challenges for both growth and inflation by further worsening competitiveness and deepening near-term deflation. In fact, two-year ahead inflation expectations have dropped considerably (by 0.8 percentage points to 0.4 percent) since the exit from the exchange rate floor. The impulse response of inflation to an expectations shock (shown above) suggests this could reduce headline inflation by as much as 0.25 percentage points this year (see Figure 10).

[9] This interest rate applies only on deposits at the SNB in excess of a certain threshold. For domestic banks, this threshold is set at twenty times required reserves as of November 2014 minus any increase in cash held since then.

E. Policy Considerations

28. External shocks can trigger a prolonged period of low inflation. The empirical evidence points to significant and long-lasting effects on headline inflation from external shocks, whereas domestic factors are currently somewhat less important, in particular for Poland and Sweden where output gaps are estimated to be rapidly narrowing. These effects have occurred through direct and indirect first-round effects, as well as second-round effects working through inflation expectations. Considering the recent commodity price declines and the lags with which these translate into headline inflation, inflation would likely remain below target for a protracted period in the absence of shocks in the opposite direction that would push up inflation.

29. Persistent bouts of disinflation can be problematic. While temporary shocks, such as a fall in oil prices that lowers inflation, may not be problematic, longer periods of very low inflation can have deleterious effects. Importantly, such periods could lead to inflation expectations becoming unanchored, which would undermine the credibility and efficacy of monetary policy. Indeed, a period of protracted disinflation can raise the risk of a deflationary spiral. In addition, very low inflation, once embedded in inflation expectations, can complicate real wage adjustment in the presence of nominal wage rigidities and increase the real value of debt, which might trigger deleveraging or make it more severe. Just as low inflation may worsen tax revenue and complicate fiscal adjustment, very low inflation can also complicate monetary policy by making it more difficult to reduce real interest rates as necessary in response to shocks.

30. This suggests that monetary policy should continue to ensure that prolonged low inflation does not become entrenched in inflation expectations. As noted above, it can be difficult to distinguish in real time between shocks with temporary effects on headline inflation and more protracted shocks, which could impact inflation expectations. Inflation expectations have been declining in the four countries we examine, and our analysis suggests that second-round effects from external shocks could impact inflation going forward.

31. The specific monetary policy response will depend on country-specific circumstances. Countries differ in their available conventional monetary policy space, as well as their existing macroprudential frameworks to limit financial stability risks. In addition, the need to stimulate the real economy may vary, with impacts on the output gap and inflation complicated by monetary policy transmission lags. Fiscal policy can also play a role in supporting the real economy and lifting inflation. Nonetheless, challenges may arise owing to asynchronous monetary policies among major central banks, which could subject small open economies to sudden capital flow movements.

- **Conventional monetary policy.** Countries with sufficient conventional monetary policy space (e.g., *Poland*) can utilize this space to further reduce policy interest rates if headline inflation continues to diverge from the target band. The decision on whether to further ease monetary policy would need to be data-driven and should take into account developments in consumer and producer price inflation, inflation expectations, credit growth, wages, and the exchange rate.

- **Negative nominal policy rate (NNPR).** Once conventional monetary space is exhausted, countries may opt to introduce NNPR as recently done in *Sweden* and *Switzerland*. However,

economic effects of NNRPs would need to be carefully monitored, including by paying close attention to the evolution of deposits, bank interest margins, profitability, capital flows, and asset prices. For example, at some point NNPRs can introduce distortions such as (i) reduced financial intermediation and weakened monetary transmission if economic agents move into cash, which could diminish the deposit base, or (ii) excessive risk-taking by financial institutions to increase returns in a low interest-rate environment. In turn, this underscores the importance of an effective macroprudential framework.

- **Quantitative easing (QE).** Countries that have exhausted conventional monetary policy space also have the option of introducing QE, provided that they have a sufficient domestic asset base to launch a credible asset purchase program. In *Switzerland,* the small outstanding stock of federal government bonds (12 percent of GDP) and already low yields on domestic assets factored into the SNB's monetary policy deliberations. Similarly, in the *Czech Republic*, where the stock of central government bonds amounts to 30 percent of GDP, the efficient implementation of domestic QE was expected to be hampered by already low bond yields and ample liquidity. Even in *Sweden*, where government debt is about 40 percent of GDP, the QE purchases announced so far are relatively small (around 2 percent of GDP), compared to QE programs in other major economies (e.g., the U.S. and Japan). The purchase of other domestic assets is possible, but the potential financial stability risks need to be weighed. Targeted credit support for firms could also be considered.

- **FX interventions or external QE (QEE).** When conventional and other unconventional policy options have been exhausted or are deemed ineffective, consideration could be given to deploying QEE. However, the decision to deploy QEE is subject to a higher threshold than, for example, QE because it has a direct impact on the exchange rate. Whenever QEE is undertaken, this should be well-integrated into the inflation targeting framework, where relevant, done in the context of an appropriate policy mix, linked to a clear domestic objective, and the initial external position should not be substantially stronger than implied by the fundamentals. In addition, a well communicated and clear exit strategy would help facilitate a smooth exit from the policy, especially where implemented via a temporary exchange rate floor or ceiling. In cases where policies may have spillovers of systemic importance, consideration should be given, including in discussions with the Fund, to alternative policies that can yield similar results for the country while minimizing potential negative spillovers.

    - ***Switzerland*:** The recent sharp exchange rate appreciation is expected to slow growth and has likely left the exchange rate overvalued. In this context, monetary easing via foreign asset purchases (given limited options for other methods of monetary easing) could help limit the near-term growth slowdown, reduce risks of inflation expectations becoming anchored at low levels (core inflation is very low at –½ percent, and 10-year bond yields are near zero), and lessen franc overvaluation. On this basis, staff recently recommended that Switzerland consider pre-announced QEE purchases, to be continued until inflation rises to safer levels.

    - ***Czech Republic*:** With exchange rate depreciation expected to have a rapid pass-through to tradable prices and headline inflation, the Czech Republic has introduced an exchange rate

floor as a tool within its inflation targeting framework. Staff has supported the move, while emphasizing that a return to a floating exchange rate once deflation risks recede—and the inflation forecast and inflation expectations, as well as wage developments, become entrenched around the central bank's target—would be appropriate.

- **Where low interest rates exacerbate financial stability risks, macroprudential policies are critical.** When monetary policy goes to extremes to raise low inflation, there is a risk of rapid credit growth and housing or other asset price bubbles (e.g., *Sweden* and *Switzerland*). In such cases, the timely adoption of appropriate macroprudential policies is essential. In *Switzerland*, various prudential measures undertaken over the last three years, aimed at reducing housing-related risks, have helped slow house price and mortgage growth, though these effects are still tentative and partial. *Sweden* has also introduced several macroprudential measures but the housing market and household borrowing have not slowed appreciably yet. It remains to be seen whether the proposed amortization requirement, if implemented, will have a more noticeable impact. Even in cases where domestic financial imbalances or asset price booms are not an immediate concern, such as in the *Czech Republic* and *Poland*, it is important to develop a comprehensive macroprudential policy framework to guard against financial stability risks that could eventually arise.

- **Fiscal policy could also play a role.** Expansionary fiscal policy can help to close a negative output gap and lift inflation. However, the desirability of this approach will depend on a number of factors, including the degree of fiscal space (including constraints from fiscal rules), the valuation of the exchange rate (as fiscal easing may worsen external imbalances), and the size of fiscal multipliers (which may be modest in small, open economies). In principle, monetary and fiscal policy measures could be coordinated—for example, the central bank could buy government debt issued to finance a one-off tax cut—to try and boost inflation. However, such coordination might be difficult to achieve in practice and could undermine the independence of the central bank. Tradeoffs may be further complicated in cases where inflation is low, but the output gap is closed. In cases where a more expansionary fiscal policy is appropriate, measures to bring forward or increase necessary public investment can help boost demand in the short-term and raise potential growth over the medium-term.

- **Policies may also need to take into account capital flows.** In particular, positive interest rate differentials vis-à-vis peer economies could result in speculative capital inflows, which are subject to sudden stops or reversals. For example, monetary and quantitative easing in the euro area could prompt short-run capital inflows in non-euro area economies, appreciating the exchange rate and further complicating reaching the inflation objective in the short run. To the extent that these capital flows are rooted in short-term search for yields, the effects on domestic asset prices could create substantial financial stability risks, including the risk of sudden outflows. Countries have a number of policy options for managing capital flows, including conventional monetary policy and exchange rate interventions, with the appropriate response depending on country-specific circumstances (IMF, 2012).

F. Conclusion

32. External factors have been important drivers of low inflation. The analysis shows that while domestic factors, particularly the output gap, did play a role in the recent spell of disinflation in the four countries examined here, their impact has been relatively limited. External factors, including the recent sharp decline in oil prices, NEER fluctuations, and spillovers from low euro area inflation, have been important drivers of disinflation. These external factors not only had direct first-round effects on headline inflation, but also had indirect first-round effects through core inflation and second-round effects through their impact on inflation expectations feeding back into prices.

33. Policy responses differed, but all four countries took action to help lift inflation. Differences in available monetary policy space had important implications for the choice of policy response. Poland cut policy interest rates and maintains conventional policy space in the context of limited domestic financial sector and external imbalances. Sweden and Switzerland introduced negative policy interest rates, with Sweden also implementing QE. The Czech Republic and Switzerland turned to exchange rate measures amid depleted conventional monetary policy space, given concerns about the effectiveness of domestic QE. While they both implemented floors to prevent further appreciation, Switzerland exited from its floor in January 2015.

34. Going forward, policy responses should take into consideration a number of factors. The inflation objective may warrant further monetary easing in itself. However, other factors to consider before deploying unconventional responses include: (i) an assessment of circumstances (including the exchange rate assessment); (ii) an assessment of policy mix and space (e.g., policy rates near zero or negative; fiscal space; in the case of QEE, clear constraints on the deployment of QE or other policies); (iii) time horizon (temporary); (iv) domestic policy objective; (v) financial stability concerns; and (vi) potential policy credibility issues that could arise from inaction or lack of adherence to stated objectives or actions. Alongside, macroprudential policy would likely have a significant role where financial stability concerns exist.

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Appendix I. Data

- **Headline inflation.** HICP inflation (year-on-year (y-o-y), quarterly, non-seasonally adjusted (NSA)) from Eurostat.

- **Core inflation.** HICP excluding energy price inflation (y-o-y, quarterly, NSA) from Eurostat. An equivalent measure of inflation is used for euro area core inflation.

- **Non-core inflation.** HICP energy price inflation (y-o-y, quarterly, NSA) from Eurostat.

- **Inflation expectations.** For Poland and Switzerland, we use 2-year ahead forecasts from Consensus Economics, which are based on surveys every other quarter. We use cubic spline interpolation to interpolate the expectations values for missing quarters. For Sweden, we use the quarterly 2-year ahead expectations average from surveys of financial market participants, firms, and households, conducted by TNS Prospera. For the Czech Republic, we use 3-year ahead inflation expectations from a survey of non-financial corporations, conducted by the Czech National Bank.

- **Output gap.** The quarterly output gap series for each country (including the euro area) is calculated using quarterly real GDP data (seasonally adjusted) from national statistics agencies and by constructing a quarterly potential real GDP series from the annual potential GDP series from the April 2015 WEO. The quarterly potential GDP series grow at a constant rate within a year, consistent with the annual growth rate of potential GDP in that year and the sum of the quarterly potential GDP level in a given year is equivalent to the annual potential GDP level. The quarterly output gap is defined as 100×(real GDP – potential GDP)/potential GDP.

- **Nominal Effective Exchange Rate (NEER).** We use the IMF's NEER index for all countries except for Sweden, where we use the KIX NEER index provided by the Riksbank. Y-o-y percentage changes in the NEER index are used in estimating the model. An increase denotes an appreciation.

- **Oil prices.** Y-o-y percentage change in the WEO quarterly average oil price per barrel.

- **Real interest rate.** The real interest rate used in equation (5) (see Appendix II) is calculated as the quarterly average nominal 3-month interbank rate less the headline inflation rate for each country, including the euro area. The nominal interest rate series is taken from Haver Analytics.

- **Administered prices inflation.** Y-o-y quarterly administered price inflation for the Czech Republic and Poland are taken from Eurostat.

- **Tax dummy.** For the Czech Republic, the "imputed contribution of taxes to headline inflation" is calculated as the difference between headline HICP inflation and HICP inflation at constant tax rates. We then construct a tax dummy: the dummy is 0 if the imputed contribution of taxes to headline inflation is less than 1; the tax dummy is 1 if the imputed contribution of taxes to headline inflation is greater than or equal to 1.

Appendix II. Main Empirical Methodology and Results

Empirical approach

We seek to disentangle the effects of domestic and external factors on headline inflation. Separating headline inflation into core inflation and non-core inflation (i.e., energy) allows us to distinguish between direct and indirect first-round effects of shocks. For example, an oil price shock will impact non-core inflation directly but might also affect core inflation through input prices. In addition, we assess effects of shocks on inflation that work through the price setting and expectations mechanism—the so-called second-round effects. This allows us to document how different domestic and external factors impact headline inflation through the different channels. Domestic factors are captured by the impact of the output gap on inflation. External factors are captured by oil price changes, spillovers from euro area core inflation, and NEER fluctuations.

We employ a semi-structural empirical modeling approach. We start with the identity of headline inflation as the weighted sum of core and non-core inflation. Core inflation is modeled as a hybrid open-economy Phillips curve equation, which includes lagged core inflation, forward-looking expectations, and domestic and external variables. Non-core inflation is linked to external factors only. Inflation expectations are modeled based on all domestic and external factors impacting headline inflation. This allows us to capture the second-round effects from shocks.

The system of equations is estimated using the SUR approach to account for possible correlation between the error terms across equations. As CPI baskets differ across countries but common factors feed into inflation dynamics across the sample, we estimate the SUR system for each of the four countries individually. The system is estimated using quarterly data over the longest sample period for which all variables are available–with sample periods up to 2014Q ranging between 12 and 17 years for our four countries (see below).

Main system of SUR equations

Four equations represent the country-specific system of equations estimated using the SUR approach. Let π_t^{HICP} denote headline inflation, π_t^{core} denote core inflation, $\pi_t^{noncore}$ denote non-core inflation (energy), and w_t^{core} ($w_t^{noncore}$) denote the weight in the consumption basket of the core (non-core) components. Also, let $\pi_t^{E\_2yr}$ denote (2-year ahead) inflation expectations[1] formed at period t, and $Ygap_t$ denote the domestic output gap. External factors include NEER fluctuations ($NEER_t$), oil price changes (oil_t^{all}), and euro area core inflation ($\pi_t^{EA\_core}$). The component of oil price changes due to global aggregate demand is denoted oil_t^D (see Appendix III).

[1] Three-year ahead inflation expectations are used for the Czech Republic.

- **Headline inflation identity.** Including this indentify in the estimation of the system means minimizing the weighted sum of squared error terms for equations (2) and (3), with the weights corresponding to the weights of core and noncore inflation in headline inflation.

  (1) $\pi_t^{HICP} = \mathrm{w}_t^{core}\pi_t^{core} + \mathrm{w}_t^{noncore}\pi_t^{noncore}$

- **Core inflation.** We model core inflation using a hybrid open-economy Phillips curve (Gali and others, 2001; Svensson, 2000), with the constraint that the coefficients on the backward and forward-looking inflation terms sum up to 1 (Mavroeidis, 2005). To control for potential endogeneity or multicollinearity issues when estimating the system, we use predicted values from equations (5), (6), and (7) for the output gap, NEER changes, and euro area core inflation, respectively (see below). For the Czech Republic a dummy variable for changes in indirect and excise taxes is also included when estimating the system of equations.[2]

  (2) $\pi_t^{core} = \alpha_{21} + \alpha_{22}\pi_{t-1}^{core} + (1-\alpha_{22})\pi_{t-1}^{E_{2yr}} + \alpha_{23}Ygap_t + \alpha_{24}NEER_t$

  $$+\alpha_{25}oil_t^D + \alpha_{26}\pi_t^{EA\_core} + \varepsilon_t^{core}$$

- **Non-core inflation**. Non-core inflation is a function of changes in oil prices and the NEER, using predicted NEER values from equation (6) when estimating the model. Iossifov and Podpiera (2014) find administered prices are also important in recent inflation developments for the Czech Republic and Poland, so administered price inflation is also included in the non-core equations for these two countries as an additional variable.

  (3) $\pi_t^{noncore} = \alpha_{31} + \alpha_{32}\pi_{t-1}^{noncore} + \alpha_{33}NEER_t + \alpha_{34}oil_t^{all} + \varepsilon_t^{HICP}$

- **Inflation expectations.** We assume inflation expectations are formed based on all available information at time *t*, including the domestic and external factors affecting core and non-core inflation, as well as the previous period's inflation expectations.

  (4) $\pi_t^{E\_2yr} = \alpha_{41} + \alpha_{42}\pi_{t-1}^{E\_2yr} + \alpha_{43}Ygap_t + \alpha_{44}NEER_t + \alpha_{45}oil_t^{all} + \alpha_{46}\pi_t^{EA\_core} + \varepsilon_t^{E\_2yr}$

Country-specific auxiliary equations (estimated outside the SUR system)

We also estimate equations for some exogenous variables outside the system and use predicted values to control for potential endogeneity issues. Within a given quarter, the NEER changes could be affected by contemporaneous feedback from inflation (or inflation expectations). Additionally, any potential measurement errors associated with the output gap may be correlated with the contemporaneous error terms in the inflation equations. Hence, we use predicted values for the output gap (from an IS-curve-type regression) and NEER changes when estimating the main

[2] We only have the imputed contribution of taxes to headline inflation (HICP inflation minus HICP inflation at constant tax rates). As we do not have the weights for core and non-core inflation at constant tax rates, unlike in Iossifov and Podpiera (2014), we cannot use the imputed contribution of taxes to headline HICP inflation in equation (1). Hence, we use a dummy for the tax changes in the core inflation equation instead.

system of equations. Equations (5) and (6) describe the country-specific equations for the output gap and NEER changes, estimated outside the SUR system.

(5) $Ygap_t = \beta_{21} + \beta_{22} Ygap_{t-1} + \beta_{23} Libor_{t-4} + \varepsilon_t^{Ygap}$

(6) $NEER_t = \beta_{11} + \beta_{12} NEER_{t-1} + \beta_{13} NEER_{t-2} + \varepsilon_t^{NEER}$

Euro area core inflation

Domestic core inflation and euro area core inflation may also be affected by common global shocks not explicitly controlled for in our system of equations. This could induce correlations in the error term of domestic core inflation and euro area core inflation. To preserve consistency across countries, we estimate an equation for euro area core inflation (similar to that of the country specific core inflation equation) outside of the system, rather than including an equation for euro area core within the SUR system for each country. We then use predicted values from the euro area core inflation equation when estimating the system of equations for each country i described above. The euro area core inflation equation also allows us to distinguish between euro area specific factors and external factors. This allows us to identify both how domestic euro area developments and global factors spill over into country i inflation through euro area trade (see main text).

The empirical approach to estimate euro area core inflation (equations (7) to (10)) is similar to the one described above. As with the estimation for our non-euro area countries, we use predicted values for the euro area output gap and NEER changes to control for potential endogeneity issues. Since the euro area reflects a relatively large share of the world economy, coefficient estimates for contemporaneous oil price changes due to global aggregate demand (oil_t^D) may also suffer from endogeneity bias. Thus, when estimating equation (7), we use the predicted value of the component of oil price changes due to global aggregate demand, which we treat as a persistent random variable in equation (10).

(7) $\pi_t^{EA\_core} = \alpha_{41} + \alpha_{42} \pi_{t-1}^{EA\_core} + \alpha_{43} Ygap_t^{EA} + \alpha_{44} NEER_{t-2}^{EA} + \alpha_{45} oil_t^D + \varepsilon_t^{EA\_core}$

(8) $Ygap_t^{EA} = \beta_{41} + \beta_{42} Ygap_{t-1}^{EA} + \beta_{43} Euribor_{t-4} + \varepsilon_t^{EA\_Ygap}$

(9) $NEER_t^{EA} = \beta_{31} + \beta_{32} NEER_{t-1}^{EA} + \beta_{33} NEER_{t-2}^{EA} + \varepsilon_t^{EA\_NEER}$

(10) $oil_t^D = \beta_{51} + \beta_{52} oil_{t-1}^D + \beta_{53} oil_{t-2}^D + \varepsilon_t^{oil}$

Historical decomposition

The historical decomposition accounts for the contribution of domestic and external factors including their lagged effects. Following Burbidge and Harrison (1985), we estimate the individual contributions of each domestic and external factor to the headline inflation over the sample period. Equations (2), (3), and (4) above essentially describe core inflation, non-core inflation, and inflation expectations as AR(1) processes with some external "shocks" (i.e., NEER, oil prices and euro area core inflation). Using backward substitution, core inflation, noncore inflation and inflation expectations at each point in time can be represented as a function of initial values plus all the external shocks as

well as the residuals in the model, as represented by equations (11), (12), and (13), respectively, below. Also, when constructing the decompositions, for the external factors we set the coefficient on an external factor equal to zero if it is insignificant and a test of joint significance of the coefficients on that factor across equations (using the Wald test) is not significant at the 5 percent level.

$$(11)\ \pi_t^{core} = \alpha_{21}\sum_{j=0}^{t-1}\alpha_{22}^{j} + \alpha_{22}^{t}\pi_0^{core} + (1-\alpha_{22})\sum_{j=0}^{t-1}\alpha_{22}^{j}\,\pi_{t-1-j}^{E\_2yr} + \alpha_{23}\sum_{j=0}^{t-1}\alpha_{22}^{j}\,Ygap_{t-j} + \alpha_{24}\sum_{j=0}^{t-1}\alpha_{22}^{j}\,NEER_{t-j} + \alpha_{25}\sum_{j=0}^{t-1}\alpha_{22}^{j}\,oil_{t-j}^{D} + \alpha_{26}\sum_{j=0}^{t-1}\alpha_{22}^{j}\,\pi_{t-j}^{EA\_core} + \sum_{j=0}^{t-1}\alpha_{22}^{j}\,\varepsilon_{t-j}^{core}$$

$$(12)\ \pi_t^{noncore} = \alpha_{31}\sum_{j=0}^{t-1}\alpha_{32}^{j} + \alpha_{32}^{t}\pi_0^{noncore} + \alpha_{33}\sum_{j=0}^{t-1}\alpha_{32}^{j}\,NEER_{t-j} + \alpha_{34}\sum_{j=0}^{t-1}\alpha_{32}^{j}\,oil_{t-j}^{all} + \sum_{j=0}^{t-1}\alpha_{32}^{j}\,\varepsilon_{t-j}^{noncore}$$

$$(13)\ \pi_t^{E\_2yr} = \alpha_{41}\sum_{j=0}^{t-1}\alpha_{42}^{j} + \alpha_{42}^{t}\pi_0^{E\_2yr} + \alpha_{43}\sum_{j=0}^{t-1}\alpha_{42}^{j}\,Ygap_{t-j} + \alpha_{44}\sum_{j=0}^{t-1}\alpha_{42}^{j}\,NEER_{t-j} + \alpha_{45}\sum_{j=0}^{t-1}\alpha_{42}^{j}\,oil_{t-j}^{all} + \alpha_{46}\sum_{j=0}^{t-1}\alpha_{42}^{j}\,\pi_{t-j}^{EA\_core} + \sum_{j=0}^{t-1}\alpha_{42}^{j}\,\varepsilon_{t-j}^{E\_2yr}$$

Other estimation details

The sample sizes vary across countries. The biggest constraint on the length of the sample is the availability of inflation expectations data. In most cases, except Poland, the panel is unbalanced. Sample periods for each country are as follows:

- **Czech Republic.** The model is estimated over 2003Q1–2014Q4 (184 total system observations).
- **Poland.** The model is estimated over 2003Q2–2014Q4 (188 total system observations).
- **Sweden**. The model is estimated over 1997Q2–2014Q4 (260 total system observations).
- **Switzerland**. The model is estimated over 1999Q1–2014Q4 (200 total system observations).

Table AII.1. Coefficient Estimates[1/]

RESULTS	Czech Rep.		Poland		Sweden		Switzerland	
Core inflation equation								
core(-1)	0.6787	***	0.7546	***	0.8995	***	0.7895	***
	0.0904		*0.0443*		*0.0630*		*0.0500*	
inf. exp(-1)	0.3213		0.2454		0.1005		0.2105	
ygap_hat	0.0548		0.2516	***	0.0433	*	0.0398	**
	0.0345		*0.0805*		*0.0232*		*0.0191*	
neer_hat	-0.0788	***	-0.0382	***	-0.0323	***	-0.0284	***
	0.0249		*0.0067*		*0.0085*		*0.0071*	
oil_d	0.0212	***	0.0038		-0.0003		0.0002	
	0.0045		*0.0027*		*0.0020*		*0.0014*	
ea_core_hat	0.3648		0.3415	***	-0.0575		0.1145	**
	0.2540		*0.1250*		*0.0742*		*0.0491*	
tax dummy	0.6560	***						
	0.1853							
Non-core inflation equation								
noncore(-1)	0.7723	***	0.6040	***	0.6833	***	0.4710	***
	0.0719		*0.0770*		*0.0585*		*0.0448*	
neer_hat	-0.1359	*	-0.0440	*	-0.1076	*	-0.1588	*
	0.0788		*0.0237*		*0.0597*		*0.0905*	
oil	0.0352	***	0.0396	***	0.0589	***	0.1919	***
	0.0103		*0.0069*		*0.0071*		*0.0129*	
admin	0.2975	***	0.5490	***				
	0.1025		*0.1364*					
Inflation expectations equation								
exp(-1)	0.3436	***	0.7428	***	0.6535	***	0.6597	***
	0.1180		*0.0781*		*0.0942*		*0.0849*	
ygap_hat	0.0228	*	0.0394	*	0.0224	*	-0.0015	
	0.0139		*0.0207*		*0.0136*		*0.0138*	
neer_hat	-0.0051		-0.0053	***	0.0070		-0.0097	*
	0.0119		*0.0020*		*0.0063*		*0.0051*	
oil	0.0035	***	0.0027	***	0.0022	***	0.0015	***
	0.0014		*0.0005*		*0.0008*		*0.0006*	
ea_core_hat	0.2230	**	-0.0359		0.1454	**	0.0371	
	0.0933		*0.0340*		*0.0729*		*0.0353*	

Source: IMF staff calculations.

1/ Standard errors in italics below coefficients. ***, **, * indicate significance at 1, 5, and 10 percent levels.

Coefficient on "inf. exp(-1)" equals "1-core(-1)" (equation (2)) and does not have a separate standard error entry.

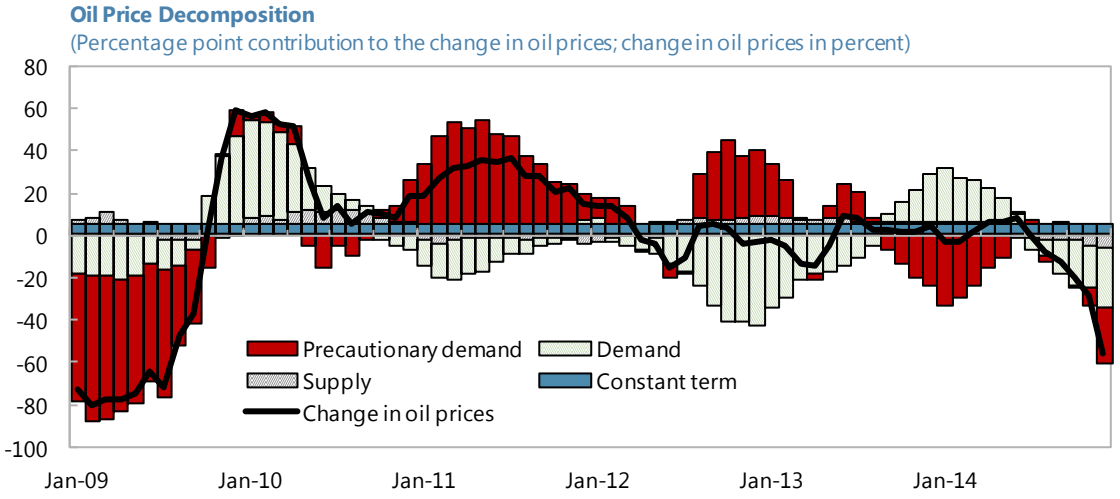
Appendix III. Disentangling World Oil Supply and Demand Shocks

We decompose oil prices into world demand and supply shock components. To disentangle the drivers of world oil price fluctuations, we use a three-variable vector autoregression (VAR), including world oil production, world economic activity (dry cargo bulk freight rates), and the price of oil. Following the identification strategy in Kilian (2009), we decompose the historical oil price into three components: (i) world commodity/aggregate demand shocks, (ii) world oil supply shocks, and (iii) world oil market shocks, which captures precautionary demand associated with concerns about future oil supply. Figure AIII.1 illustrates the contributions from each of the three components.

This allows us to distinguish between global aggregate demand factors that may have an effect beyond just the oil price, supply shocks, and precautionary demand factors. It is important to differentiate between global demand shocks, oil-specific precautionary demand shocks, and supply shocks. Global aggregate demand shocks that drive up the price of oil may have effects beyond their impact on oil prices. Namely, as demand for other goods increase as well, firms may have greater ability to pass through higher oil prices to their customers. Effects from precautionary demand shocks, driven by expectations about future demand and supply, may be more nebulous, particularly when they offset the impact of current global demand conditions on the observed oil price. In particular, even if precautionary demand shocks are pushing the oil price up, if current demand conditions are pushing it in the other direction, firms may not be as able to pass through increases in input cost due to oil price rises as easily. Actual supply shocks have typically been small in recent years, though, like precautionary demand shocks, their effects can be ambiguous.

Figure AIII.1. Disentangling Oil Supply and Oil Demand Shocks

Lower aggregate demand led to a drop in oil prices in 2014, with supply and precautionary demand factors also becoming increasingly relevant toward the end of the year.



Source: IMF staff calculations.

The results from this exercise are in line with other approaches that attempt to disentangle the effects of supply and demand shocks on the oil price. Box 1.1 in the April 2015 WEO looks at how much of recent oil price changes are attributable to supply and demand shocks. One approach finds that between October 2014 and January 2014 about 64 percent of oil price changes were due to supply and 36 percent due to demand. Their measure of supply is most comparable to the sum of supply and precautionary demand shocks in our decomposition. For supply and precautionary demand components combined, we find they accounted for more than half of the decline in oil prices in the last couple of months of 2014, which is broadly in line with the WEO results.