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CROSS-COUNTRY REPORT ON SPILLOVERS

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July 2016

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CROSS-COUNTRY REPORT ON SPILLOVERS

SELECTED ISSUES FOR THE 2016 ARTICLE IV CONSULTATIONS WITH THE REPUBLIC OF POLAND AND SWEDEN

June 10, 2016

Approved By
European Department

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CONTENTS

ADAPTING TO SPILLOVERS FROM UNCONVENTIONAL MONETARY POLICIES

A. Introduction

1. Central banks adopted a range of unconventional monetary policies (UMPs) to revive growth and inflation in the wake of the global financial crisis. Since the onset of the financial crisis, the U.S. Federal Reserve (Fed) undertook substantial securities purchases to put downward pressure on term and credit spreads and thereby ease financial conditions.[1] This quantitative easing (QE) ended in October 2014, and with recovery in the U.S. more advanced, the Fed decided to begin raising interest rates in December 2015. On the other side of the Atlantic, the European Central Bank (ECB) introduced a number of nonstandard monetary policy measures after the intensification of the crisis in September 2008, including Enhanced Credit Support in June 2009, the Securities Markets Programme in 2010, and Outright Monetary Transactions in 2012.[2] From mid-2014 the ECB implemented a negative rate on its deposit facility and targeted longer-term refinancing operations (TLTROs) to boost lending. Purchases of asset backed securities (ABS) and covered bonds (ABSPP and CBPP3) began in late 2014 to lower private borrowing costs and stimulate issuance. In January 2015, the ECB announced an expanded asset purchase program (APP), adding the purchase of government and public sector securities to those earlier programs, with the APP further expanded in April 2016. The APP is more substantial and prolonged than its earlier UMP, comparable with the QE by the Fed, underscoring the ECB's commitment to its price stability mandate.

2. UMP in the euro area is ultimately expected to benefit neighboring countries, but they may face spillovers in the interim and the divergence with U.S. monetary policies could add to financial volatility. The IMF supports UMP in the euro area to achieve the ECB's price stability objective and to bolster the recovery in Europe. To the extent that lower bond yields in the euro area reduce those in neighboring countries, public sector debt service costs will decline over time, enhancing their fiscal space. As euro area growth and inflation improves in time, neighboring countries would also benefit from stronger exports and less external drag on their own inflation.[3] Nonetheless, until higher inflation in the euro area allows the ECB to unwind stimulus, neighboring countries could face capital inflows resulting in currency appreciation and/or declines in domestic yields, with potential implications for their growth, inflation, lending activity, and asset prices.

3. The extensive literature on the effects of Fed UMP finds significant financial spillovers to other countries, especially the emerging markets (EMs). In general, the literature finds that QE

[1] http://www.federalreserve.gov/monetarypolicy/bst.htm

[2] https://www.ecb.europa.eu/mopo/decisions/html/index.en.html

[3] IMF Country Report No 15/184.

was effective in reducing term spreads on U.S. Treasuries. This in turn affected financial conditions in EMs by raising capital inflows, reducing long-term bond yields, boosting equity prices, and driving exchange rate appreciation.[4] But the evidence is not so clear-cut regarding the strength of spillovers to the real economy.[5]

4. Less attention has been devoted to the external impact of euro area UMP to date. The existing research finds spillovers from the ECB's unconventional monetary policy to other economies, on both financial and real variables. The IMF's 2015 Spillover Report finds positive spillovers on other countries from news about better growth prospects in the euro area or U.S., although these spillovers are dampened by asynchronous monetary policies. Falagiarda and others (2015) find significant spillovers from the ECB's nonstandard monetary policy on sovereign bond yields of Central and Eastern European countries. Kucharcukova and others (2014) conclude that unconventional measures have generated diverse responses across six neighboring countries. Exchange rates respond rather quickly, but effects on the real economy are found only for some countries, and inflation is largely unaffected.

5. This paper examines the nature and scale of spillovers to a number of European countries from monetary policies in the euro area and U.S. using three different approaches. The analysis focuses on selected non-euro area countries in Europe: Czech Republic, Denmark, Hungary, Poland, and Sweden. After a brief summary of developments in key indicators in these countries, an event study approach is employed to investigate the presence and magnitude of announcement effects from the ECB's UMP on these countries. This is followed by a country VAR analysis focused on identifying spillovers at the country level while controlling for domestic policy. Finally, a global VAR analysis is used to assess the domestic and global impact of spillovers while accounting for cross-country linkages among the selected economies.

6. The paper finds some financial spillovers from ECB UMP to the five countries, but the analytical results are not always statistically or economically significant. Recent developments in these countries' sovereign bond yields and exchange rates are indicative of potential spillovers. The paper's most consistent analytical finding is for spillovers to lower domestic bond yields, with the potential for knock-on effects on credit expansion and asset prices. More recently, there are also findings of upward pressure on the exchange rate in the event study. Notably, the ongoing APP is found to have exerted much larger financial spillover effects compared to earlier ECB UMP, although these effects may have been partly counteracted by market expectations of tighter U.S. monetary policy. As discussed further, the analytical results may be affected by a number of factors, including domestic policy reactions, market expectations of policy actions by the ECB and Fed, and by the changing nature of ECB's UMP as it first dealt with the euro area crisis and then tackled low inflation.

[4] See, for example, Neely (2010) and Tillmann (2014).

[5] See, for example, Aizernman and others (2014) and Eichengreen and Gupta (2014), who conclude that countries with stronger fundamentals as well as larger and deeper financial markets experience stronger spillover effects. At the same time, Mishra and others (2014) find that countries with stronger fundamentals experience smaller spillover effects. IMF (2013) finds positive domestic effects of UMP, but mixed effects on the rest of the world. Mishra and others (2014) find that countries with stronger fundamentals experience smaller spillover effects.

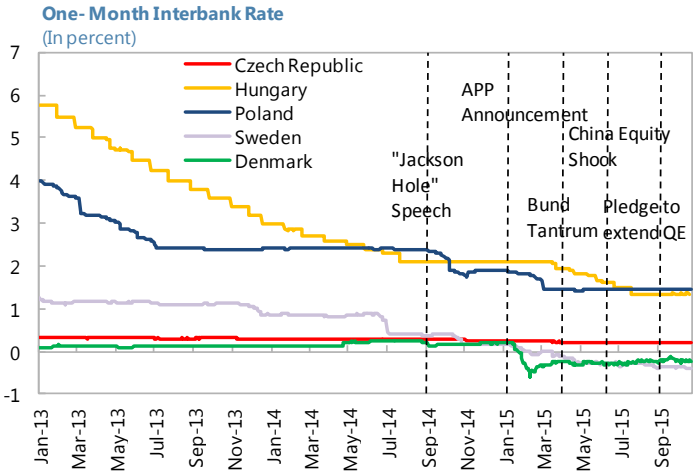
B. Recent Developments and Stylized Facts

7. In reviewing recent developments for signs of spillovers from ECB QE, this section focuses on financial channels. By pushing up output and inflation in the euro area, ECB UMP is expected to increase euro area demand with positive real spillovers to neighboring economies through the trade channel. But these positive effects on neighboring countries unfold over quarters and years, and are not expected to be readily evident in charts given many other sources of shocks. In contrast, lower interest rates and term spreads in the euro area are expected to increase interest differentials with neighboring economies, putting upward pressure on their exchange rates and downward pressure on their yield curves. Equity returns could also respond quickly to expectations of higher growth and to lower bond yields.

8. The nature of financial impacts depends on domestic policy reactions and market expectations for such reactions. Domestic policymakers may respond to external UMP by cutting policy rates, or even by undertaking domestic UMP, to help maintain currency pegs or to moderate currency appreciation.[6] In cases where such a response occurs, the exchange rate impact would be reduced but the decline in the yield curve and in private sector lending costs would be greater. Such an easing in monetary conditions can also moderate financial market volatility which may encourage investors to "search for yield", shifting capital flows to emerging markets rather than safe havens, reinforcing yield declines in the former and partially offsetting declines in the latter.

9. Signs of spillovers are most evident in government bond yields, and currencies have appreciated against the euro, yet domestic factors also played a role in these developments:

- ***Policy rates.*** Key UMP steps by the ECB are denoted in the text chart on one-month interbank interest rates. Hungary, Poland, and Sweden were in the process of reducing their policy rates during 2014–15. Poland lowered rates amid a bumpy recovery and low inflation while facing heightened external risks; the latest rate cut in March 2015 came three months after the ECB's APP and was largely in response to continuing deflation. Hungary went through an easing cycle with rate cuts over two years until July 2014 and then in March 2015 cuts were renewed to counter deflation. In the case of Sweden, rate cuts in 2014 and earlier were driven by persistently low inflation. A notable decline in inflation expectations

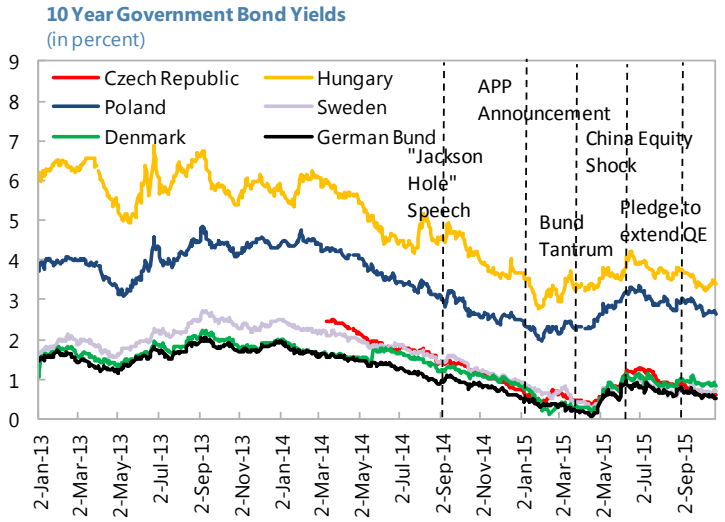


Source: Haver Analytics.

[6] Traditionally, such a response would be aimed at protecting exports and growth, but in an inflation-targeting regime, the central bank may also consider avoiding a decline in inflation from exchange rate pass-through.

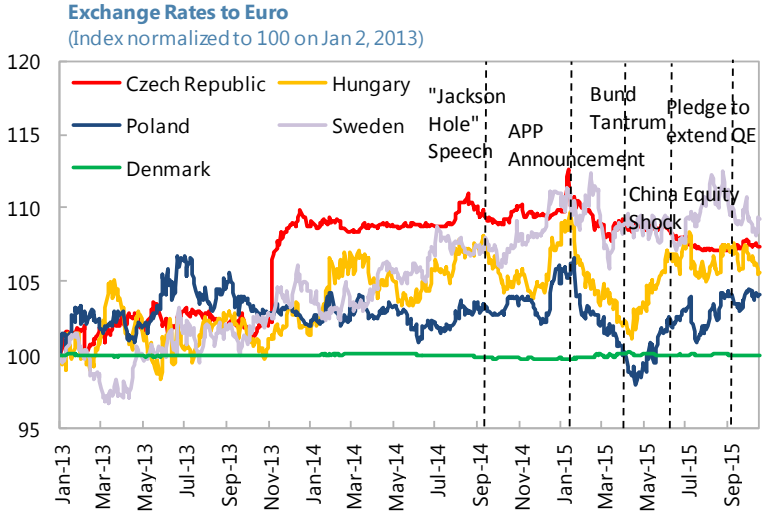
preceded the shift to negative rates and domestic QE in February 2015, although this move was also soon after the APP. Denmark adopted even more negative rates at this time to counter large capital inflows speculating against the Danish peg to the euro after the Swiss National Bank exited its currency ceiling.

- ***Government bond yields.*** Bond yields had been declining during 2014, in part reflecting domestic rate cuts noted above, but also declines in euro area bond yields owing to growing market expectations of stronger actions by the ECB. Yield declines continued following President Draghi's speech in Jackson Hole in August 2014. But the downtrend was halted by the reversal of Bund yields in Spring 2015, renewed tensions over Greece, and heightened global financial volatility associated with China's stock market turmoil in the summer. Although the high correlation of the bond yields of these countries with the Bund yield is evident, this bivariate relation likely overstates spillovers as (i) shocks to global growth and inflation may create correlations in domestic monetary policy and expectations for domestic interest rates, and (ii) as noted earlier, domestic monetary decisions may take into account the tightening of domestic monetary conditions implied by currency appreciation owing to lower Bund yields, also lowering prospective policy rates.



Source: Bloomberg.

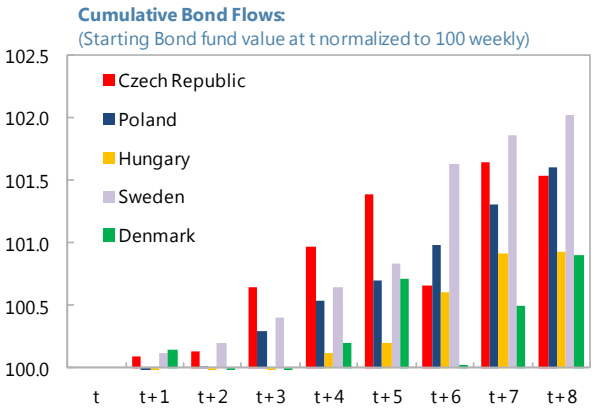
- ***Exchange rate.*** The exchange rates of the four countries (excluding Denmark) have appreciated against the euro since early 2013. The Czech koruna experienced the most significant appreciation, prompting the adoption of an exchange rate floor in November 2013 as an additional instrument of the inflation targeting framework. The Swedish krona and Hungarian forint also appreciated notably ahead of the Jackson Hole speech, with a smaller appreciation of the Polish zloty. Following the speech, all three currencies



Sources: Haver Analytics and IMF staff calculations.

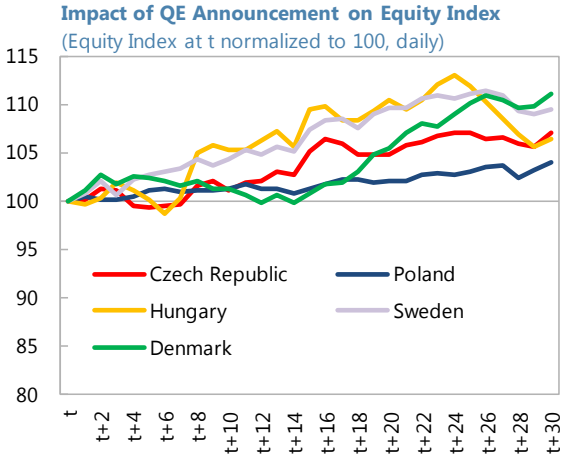
appreciated further prior to the APP announcement, with the krona and forint reaching similar appreciations to the koruna. In the first week after the APP announcement, the koruna, zloty, forint, and the krona appreciated by 1 to 2 percent against euro. Some reversal of the appreciations in Hungary and Poland took place following the first quarter of 2015 owing to domestic factors, but appreciation soon returned. By the end of 2015, these four currencies were 5–10 percent above their early 2013 levels.

- ***Capital flows.*** Balance of payment data show higher capital inflows to Poland and the Czech Republic in the first quarter of 2015 compared to 2014, mostly due to bond inflows. Other countries did not see a material increase in balance of payments capital inflows. Higher frequency mutual fund data show signs of portfolio reallocation toward non-euro area EU countries, mostly bond flows to Poland, the Czech Republic, and Sweden. There has also been some reallocation of equity funds to Sweden and Denmark. The inflows to Sweden and Denmark may be related to the adoption of domestic QE and rate cuts at this time. In Denmark, most inflows slowed down or reversed after the first month.



Sources: Haver Analytics and IMF staff calculations.

- ***Equity Returns.*** Equity markets reacted positively to the APP announcement, led by Sweden and Denmark where indices rose by around 3 percent on average in the first week. The indices continued to trend upward before stabilizing after about three weeks, with only Hungary reversing notably in the following week. Danish and Swedish markets recorded the largest gains of about 10 percent after a month, which followed the trend of expected earnings but may also partly reflect the Riksbank's adoption of UMP in February and Denmark halting government bond issuance in late January.



Source: Bloomberg and IMF staff calculations.

10. These developments may have been influenced by factors other than the ECB UMP announcements. For example, U.S. Fed monetary policy announcements, global real and financial shocks, domestic economic developments, and policy responses may have played a role. As such, a more rigorous econometric analysis is needed to help disentangle the impact of ECB UMP from other factors. The event study approach in the next section addresses some of these issues.

C. An Event Study Approach

11. This section uses an event study approach to analyze the immediate financial spillover effects of UMP announcements by the ECB. A number of recent papers use this approach to assess the economic impact of monetary policy shocks.[7] The approach addresses common challenges that arise when attempting to separate policy effects from those of other factors by controlling for a range of other variables and by focusing on a short time period around an announcement. The approach relies on high frequency data, so most studies limit their analysis to financial market indicators rather than real economic variables. As a result, the approach is not well suited to determining the persistence of policy impacts.

12. UMP events are identified using the methodology in Falagiarda and others (2015).[8] This paper covers over 70 press conferences, press releases, and speeches related to UMP measures since 2007, including President Draghi's speech in Jackson Hole in August 2014 and the decision on the APP, which broadly parallels the QE that was previously undertaken by the U.S. Fed and the Bank of England. The now ongoing APP is designed to boost the low rate of inflation in the euro area. Earlier UMP measures by the ECB were implemented during a period when banking sector distress was impairing the transmission of monetary policy to the economy, hence they were designed to boost the liquidity of the banking sector and support credit extension in certain sectors.

13. Four potential spillover channels are analyzed—sovereign bond yields, exchange rates, equity returns, and capital flows—with a special focus on the current APP program. OLS regression is used to estimate the effect of UMP announcements on two-day changes in 10-year bond yields, nominal effective exchange rates and exchange rates to the euro, equity returns, and mutual fund flows. The large number of controls includes those for domestic and foreign monetary policy decisions (including those of the Fed) and news on IMF/EU programs. The analysis covers five non-euro area EU countries: the Czech Republic, Poland, Hungary, Denmark, and Sweden. It aims to identify the key channels of spillovers, estimate the magnitude of these spillovers for each country, and explore cross-country differences in these effects. Finally, rolling OLS regressions are used to examine the differences between the financial effects of the most recent APP versus earlier UMP measures (see Annex I for a technical description). The results are summarized below.

Government Bond Yields

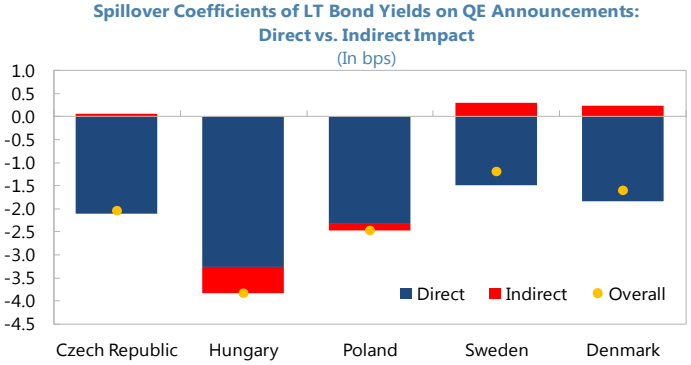
14. UMP of the ECB spilled over into lower long-term bond yields across all countries in the sample, with a larger impact on emerging markets than advanced economies. The two-day declines in long-term bond yields after UMP announcements range from around 1½ to 2½ basis

[7] Briciu and Lisi (2015); Rai and Suchanek (2014); Chen, Mancini-Griffoli, and Sahay (2014); Falagiarda, McQuade, and Tirpak (2015); Altavilla and others (2013); and IMF (2013).

[8] The authors of this paper acknowledge that it is difficult to take account of every single announcement that may have had an effect, including unofficial information of forthcoming UMP measures.

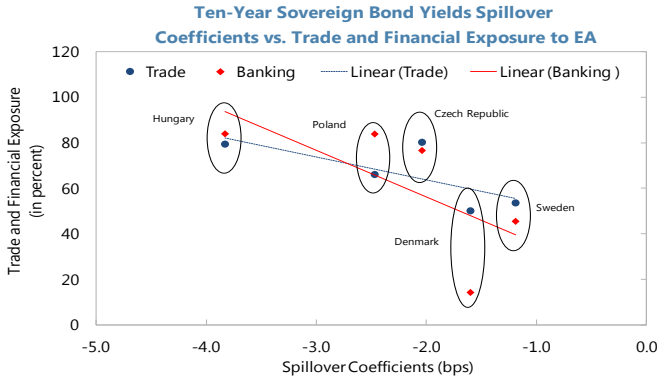
points in most countries and about 4 basis points in Hungary (see Annex I, Table A1.1), similar to the spillover magnitudes found by Falagiarda and others (2015).

15. UMP affects non-euro area long-term bond yields directly by narrowing term spreads and, to a lesser extent, indirectly by lowering financial volatility. These direct and indirect impacts reinforce each other for emerging markets (Hungary and to a smaller degree Poland), but partly offset each other in advanced economies. It appears that emerging markets attract investors in search for yield when global financial volatility is reduced, which further lowers their yields, while the safe haven benefit of investing in advanced economies is lower in these circumstances.



Note: ECB UMP affects non-EA long-term bond yields directly by narrowing term-spreads and indirectly by lowering financial market volatility. The direct impact is estimated as a coefficient on ECB UMP in a regression of bond yields on UMP announcements, VIX, and control variables. The overall effect is then estimated by purging the impact of UMP announcements on VIX and using a residual from that regression as an explanatory variable in the bond yields regression instead of VIX. The indirect impact is the difference between the overall and direct impacts. Significance levels are shown in annex tables.

16. These cross-country differences between emerging markets and advanced economies are consistent with the extent of countries' trade and financial exposure to the euro area. It is notable that emerging markets with closer trade links and higher banking sector exposure to the euro area have experienced a larger decline in yields than advanced economies in the sample. But other factors such as market liquidity or compression in risk premium may also play a role in explaining asset market reactions to the UMP announcements.



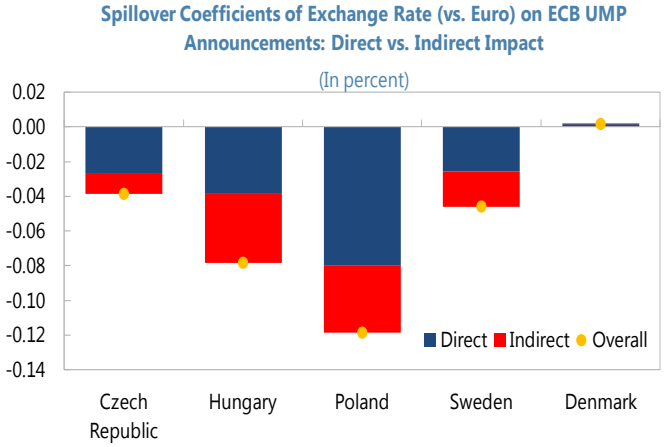
Note: Trade exposure=(export from +import to EA)/total exports and imports; banking exposure= (EA claims on the country)/country's total bank liability
Source: IMF staff calculations.

Exchange Rates

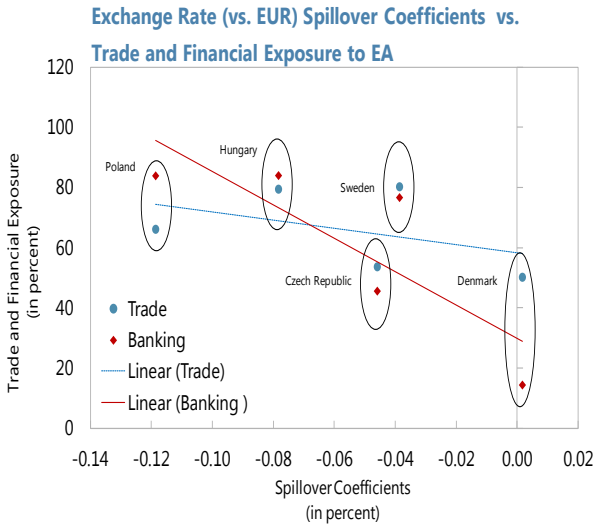
17. Exchange rates appreciated following UMP announcements, although the impact was small and not statistically significant.[9] Inflation targeters all experienced some degree of appreciation, with the Polish zloty appreciating the most (0.12 percent against the euro and 0.08 percent in nominal effective terms) (see Annex I, Tables A1.2a and A1.2b). The magnitude compared to the actual two-day appreciation following the APP announcement (close to 1.5 percent) is rather small, but not negligible. The impact seems to be driven both directly by expectations of higher growth prospects in euro area trading partners and indirectly by lower volatility. The indirect effect seems to have contributed to the appreciation of the Swedish krona as well as the Czech koruna as well, but to a smaller extent than in Hungary and Poland. Countries with

[9] The impact on Danish krone is minimal as expected owing to its pegged exchange rate regime.

stronger trade and financial linkages to the euro area saw larger appreciation (e.g., Poland and Hungary).

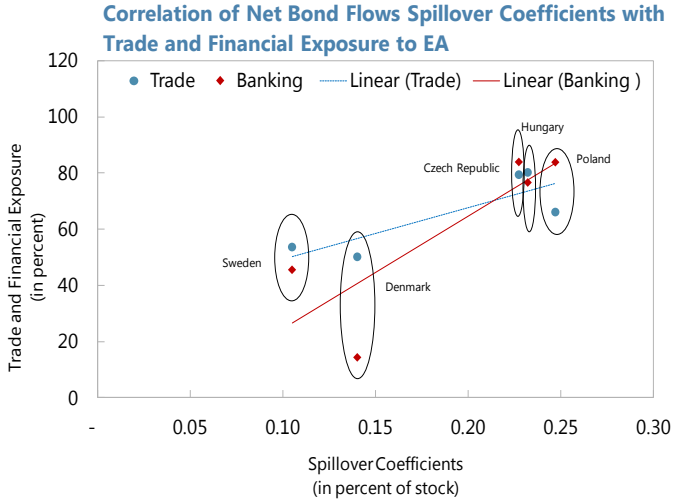


Note: ECB UMP affects non-EA exchange rates directly by higher confidence on economic performance and indirectly by lowering financial market volatility which drives capital inflows and appreciation. The direct impact is estimated as a coefficient on ECB UMP in a regression of exchange rates on UMP announcements, VIX, and control variables. The overall effect is then estimated by purging the impact of UMP announcements on VIX and using a residual from that regression as an explanatory variable in the exchange rate regression instead of VIX. The indirect impact is the difference between the overall and direct impacts. Significance levels are shown in annex tables.



Note: Trade exposure=(export from +import to EA)/total exports and imports; banking exposure= (EA claims on the country)/country's total bank liability

18. UMP announcements had limited impact on mutual fund investment flows. Bond funds investing in all countries in the sample experienced inflows, ranging from 0.1 to 0.25 percent of stock in the first week after the UMP announcements, although these amounts are not statistically significant. Emerging markets were more affected, consistent with their closer trade and financial linkages with the euro area and a propensity to search for yield when financial volatility is low. Yet, the impact on mutual fund flows may be underestimated for a number of reasons. First, the highest frequency of mutual fund flow data is weekly, which may include reversals of immediate inflows following UMP announcements. Second, portfolio investors have a tendency to react asymmetrically, with a stronger reaction to bad news than good news. Lastly, by averaging the effects of earlier UMPs and the current APP, static regressions could miss a larger spillover from APP, as discussed below.



Note: Trade exposure=(export from +import to EA)/total exports and imports; banking exposure= (EA claims on the country)/country's total bank liability;

19. Local equity returns do not seem to be affected by UMP announcements. In fact, local equity indices are more sensitive to global equity market developments and European financial volatility than to ECB policy announcements.

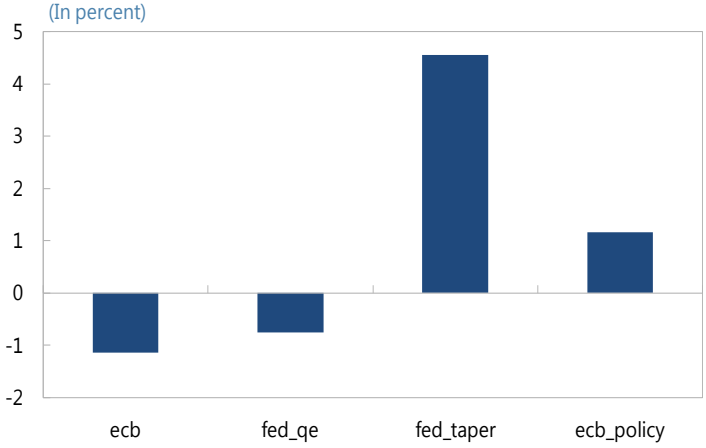
Evolution of Spillover Effects

20. Financial spillovers from the more recent APP are much stronger than earlier UMPs (Figure 1). A rolling regression is used to estimate the impact of spillovers over time to allow scope for differences between the effect of recent APP measures and those of earlier UMPs. The effects of the recent APP announcement on government bond yields are found to range from 4 basis points (Sweden) to 24 basis points (Hungary), which are statistically significant for all countries (Annex I, Table A1.6) and much greater than the full sample estimates of 1.5 to 4 basis points for those countries. Exchange rates appreciated against the euro by as much as 1.2 percent in Poland which is ten times the average estimate for earlier UMPs. Bond fund inflows increased by around ½ percent of fund stock after the APP announcement, double that following earlier UMPs. Equity returns show a positive response of up to 1 percent, led by Sweden and Denmark. These differences are consistent with the larger macroeconomic impact that APP aims to achieve in the euro area, compared with prior UMP steps aimed at facilitating monetary transmission. The statistical significance of the rolling coefficients can be found in Annex I, Tables A1.6–A1.10.

Role of Fed Policies

21. Market impacts from expectations of tighter U.S. monetary policy have gone in the opposite direction to that of ECB UMP, especially for emerging markets. In response to U.S. Fed announcements foreshadowing a tighter monetary stance, bond yields increased significantly in Hungary, Poland, and the Czech Republic, by 15, 13, and 9 basis points respectively. The Hungarian forint depreciated by close to 1 percent in nominal effective terms and 0.8 percent against the euro. Equity and bond funds faced outflows in the range of 1.5 to 2.2 percent of the existing stock across emerging markets. These reactions are consistent with expectations of a higher rate of return on U.S. assets and flight to safety as monetary policies in the euro area and the U.S. diverge. Indeed, empirical analysis suggests that Fed taper talk increased the European VIX by more than 4 percent in a two-day window, with spillovers on bond yields, exchange rates, equity returns, and mutual fund flows. Fed lift-off has so far generated limited market reaction compared to the earlier taper talk, likely because the decision was widely anticipated. But going forward, the effects could potentially be significant if the pace of tightening surprises markets.

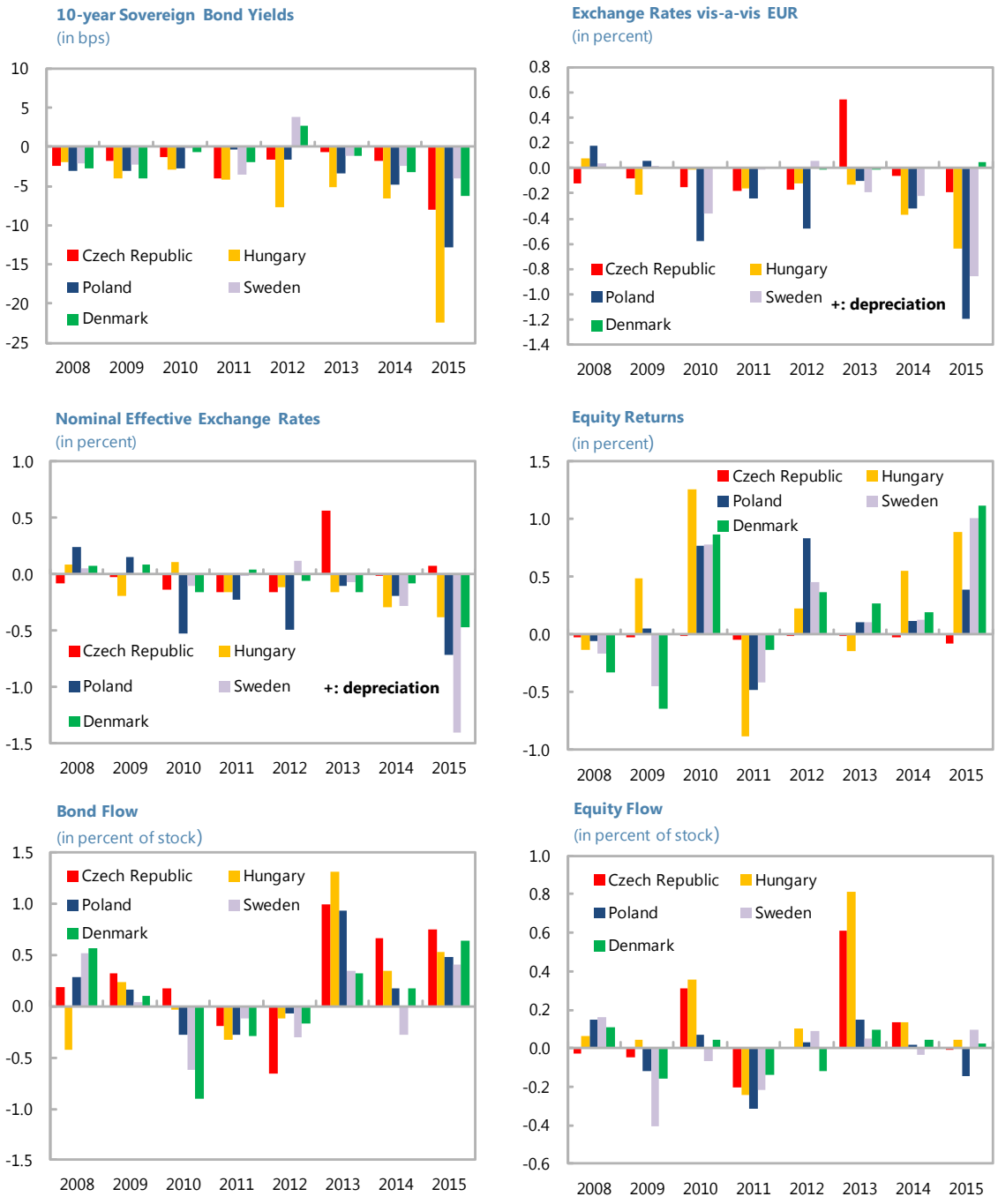
Coefficients of Explanatory Variables on European Financial Volatility
(In percent)



Note: European financial volatility (euroVIX) is regressed on the events of ECB UMP, Fed QE, Fed Taper, and ECB policy rate changes.
Source: IMF staff calculations.

Figure 1. Abnormal Movement of Selected Financial Variables Following ECB UMP Announcements

(Two-day Changes)



Sources: EPFR, Havers, QEDS, Bloomberg, DOTS, BIS, ECB WP No 1960, and IMF Staff Calculations.
Note: Rolling regressions are conducted on a 180 days window or 30 weeks in the case of capital flow regressions to see how spillover has evolved over time. The model specification remains the same as static benchmark regressions. Annual coefficients are average of the rolling coefficients of particular years.

Summary of Findings

22. The event study finds that spillovers from ECB UMP have occurred via sovereign bond yields, with the exchange rate channel becoming significant more recently. The effects on indicators of capital flows were less significant. Emerging markets are found to have experienced larger financial spillovers than advanced economies in the sample, which is consistent with their greater trade and financial exposure to the euro area and higher returns on assets—which signals a different risk class. It is notable that the ongoing APP has exerted much larger financial spillover effects compared to earlier ECB UMPs, likely reflecting its large scale consistent with its broader macroeconomic objectives. The analysis also shows that the spillover effects from the ECB UMP have been partly counteracted by market expectations of tighter U.S. monetary policy.

D. A Country-Level VAR Analysis

23. An open-economy Vector Auto Regression (VAR) can help evaluate the international transmission of monetary shocks and macroeconomic spillovers. Many studies of the economic impact of policy actions employ a VAR analysis. In the majority of studies, identification relies on the assumption that a small economy is subject to exogenous shocks from a large economy such as the United States. For example, Chinn (2013) provides evidence of international externalities from the Fed's unconventional monetary policies, particularly on exchange rates and asset prices in emerging market economies. Lim and others (2014) find that the effect of QE in the U.S. on developing countries is transmitted through liquidity, portfolio rebalancing, and confidence channels. One of the few papers focusing on ECB UMP, Kucharcukova and others (2014), finds an almost immediate effect on exchange rates, although real economic effects are present over time only in some countries, and inflation appears unaffected. However, it should be noted that standard VARs may face identification challenges, particularly when the model includes financial variables. Even though shocks from a large economy could be treated as exogenous for a small economy, the results may reflect responses to other common factors which cannot be captured by the VAR.

24. This section uses a VAR analysis to estimate the nature and scale of spillovers from ECB UMP on Denmark, Poland, and Sweden.[10] The analysis uses monthly data from January 2002 to October 2015, a sample period that covers both conventional and unconventional monetary policy regimes. A number of VARs are run for each of the three countries where each has a set of endogenous variables as well as an exogenous block. On the endogenous side, the variables are ordered starting with the country policy rate, followed by the exchange rate, inflation, and finally interpolated monthly GDP. The exogenous block comprises the variable representing ECB UMP, interpolated monthly GDP of the euro area, and the euro area inflation rate (see Annex II for a technical description).

25. Three different indicators are used to represent the stance of ECB monetary policy. Traditionally, monetary policy is represented by a short-term interest rate, but this cannot capture

[10] These countries are representative of different types of monetary policies within the sample.

UMP. A number of researchers have developed "shadow rates" to summarize the term structure of interest rates and thereby quantify the overall stance of monetary policy. For example, the Wu and Xia (2015) shadow rate builds on Black's (1995) options model for interest rates to find implied values of segments of the term structure. This shadow rate for the euro area is used as a measure of ECB UMP. A related but simpler approach is to use term spreads to represent the impact of QE or expectations of QE. So the second measure used to represent the ECB monetary stance is the 10-year German government bond yield minus the 3-month Euribor rate. However, other factors may also account for significant variation in term spreads, so we also consider a quantity rather than price measure of QE, using the increase in the ECB's holdings of securities for monetary policy purposes.[11]

26. A one standard deviation positive shock to the euro area shadow rate has economically intuitive spillover effects on interest rates and the exchange rate, though not always statistically significant. Specifically, a 20 basis point increase in the euro area shadow rate leads to an initially statistically significant increase in Swedish long-term bond yields by about 7 basis points after three months. While 10-year bond yields in Denmark and Poland are also pushed up in the first period after the shock, these effects are not found to be statistically significant. Moreover, factors other than UMP may have contributed to the observed decline of bond yields in Denmark, where the authorities suspended bond issuance from late January 2015 until October of that year in response to a speculative attack on the currency following the Swiss National Bank's decision to exit from the exchange rate peg in mid-January 2015. Exchange rate responses to the shadow rate, though economically intuitive, are not found to be statistically significant, similar to the results of the event study for the full sample period. The estimated effects on the real economy variables are also not statistically significant (Figure 2).

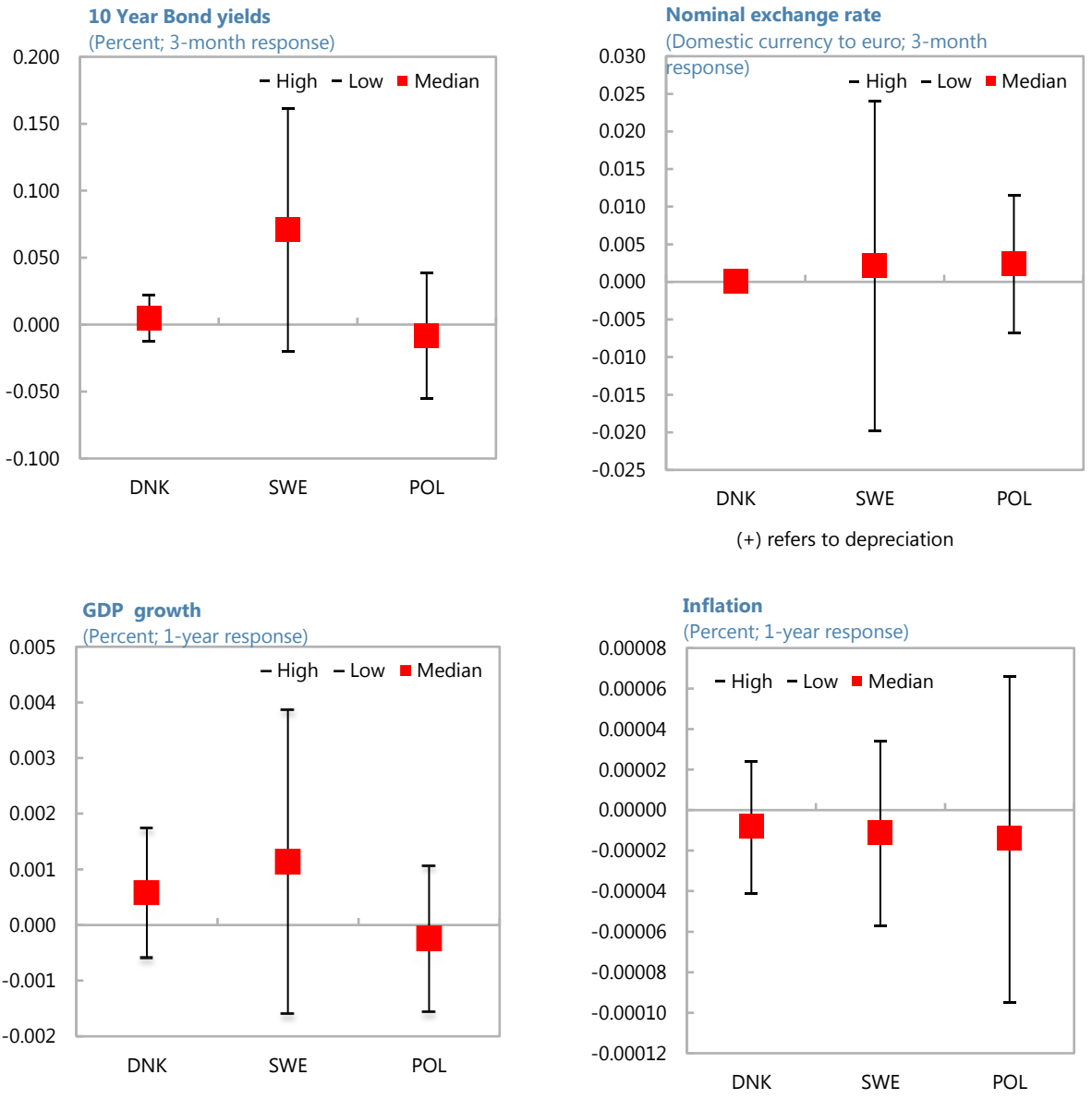
27. A shock to the euro area term spread is found to impact term spreads in all three countries and there are also more significant effects on exchange rates. Term spreads in both Denmark and Sweden initially increase by about 46 bps in response to a one standard deviation positive shock to the euro area spread--which is equivalent to 46 bps. The term spread in Poland responds by about half as much as in the other two economies. Yet, after the initial positive reaction, the term spreads in the three countries start to narrow, suggesting that ECB UMP policies may not have had a permanent effect on yield curves in neighboring economies (Figure 3). Three months after the shock, the response of the Polish zloty exchange rate to the euro is modest yet statistically significant, while the response by the Swedish krona is more sizeable, yet not quite statistically significant at a standard (95 percent) level of confidence.

28. Using ECB holdings of securities for monetary purposes to represent the ECB monetary stance produces mixed results. A one standard deviation positive shock, equivalent to EUR 2.5 billion, is applied to the ECB holdings for monetary purposes. The exchange rates in Sweden and Poland appreciate by 0.05 and 0.03 percent respectively in response to the shock. However, the

[11] Purchases of securities are identified as changes to the ECB's portfolio of securities held for monetary policy purposes (available as of July 2009). Using longer series from holdings of other securities that are not earmarked for monetary policy does not change the results.

effect appears to be temporary, with the spillover lasting for about two months following the shock. Although the responses of bond yields and real economic variables are not statistically significant, they are largely consistent with economic intuition (Figure 4).

Figure 2. Impulse-Responses for Shock to the Euro Area Shadow Rate[1]

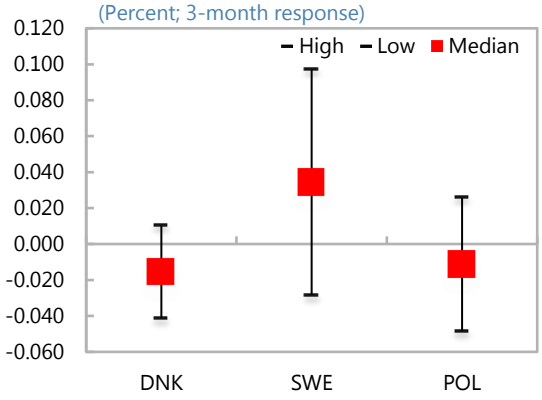


Source: IMF staff calculations.

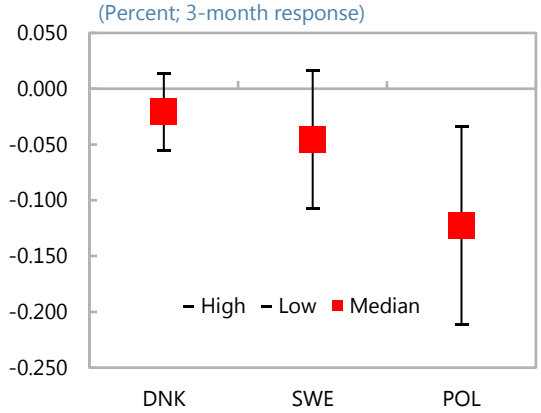
[1] Each box represents the coefficient (labeled as median) while the high and low dashes represent a 95 percent confidence interval.

Figure 3. Impulse-Responses for Shock to the Euro Area Term Spread[1 2]

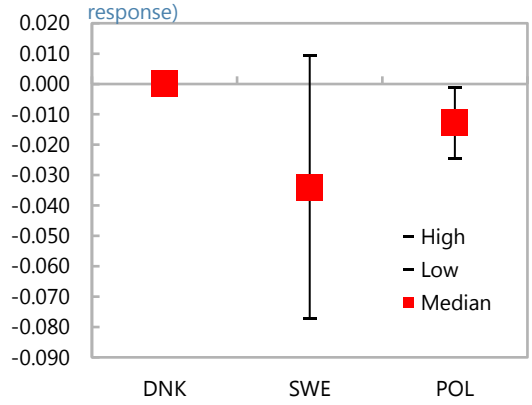
Short-term Rate
(Percent; 3-month response)



Domestic Term Spread
(Percent; 3-month response)

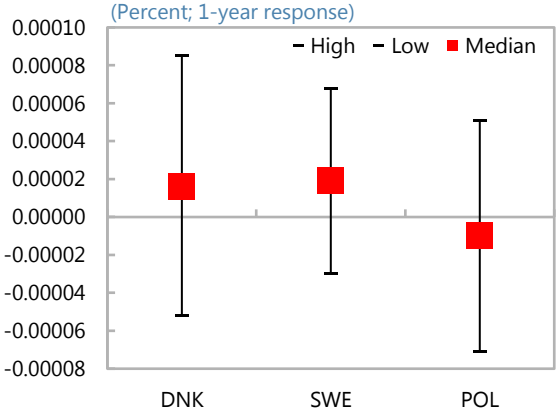


Nominal exchange rate
(Domestic currency to euro; 3-month response)

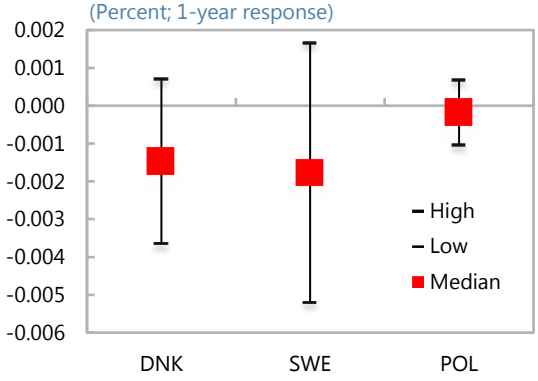


(+) refers to depreciation

Inflation
(Percent; 1-year response)

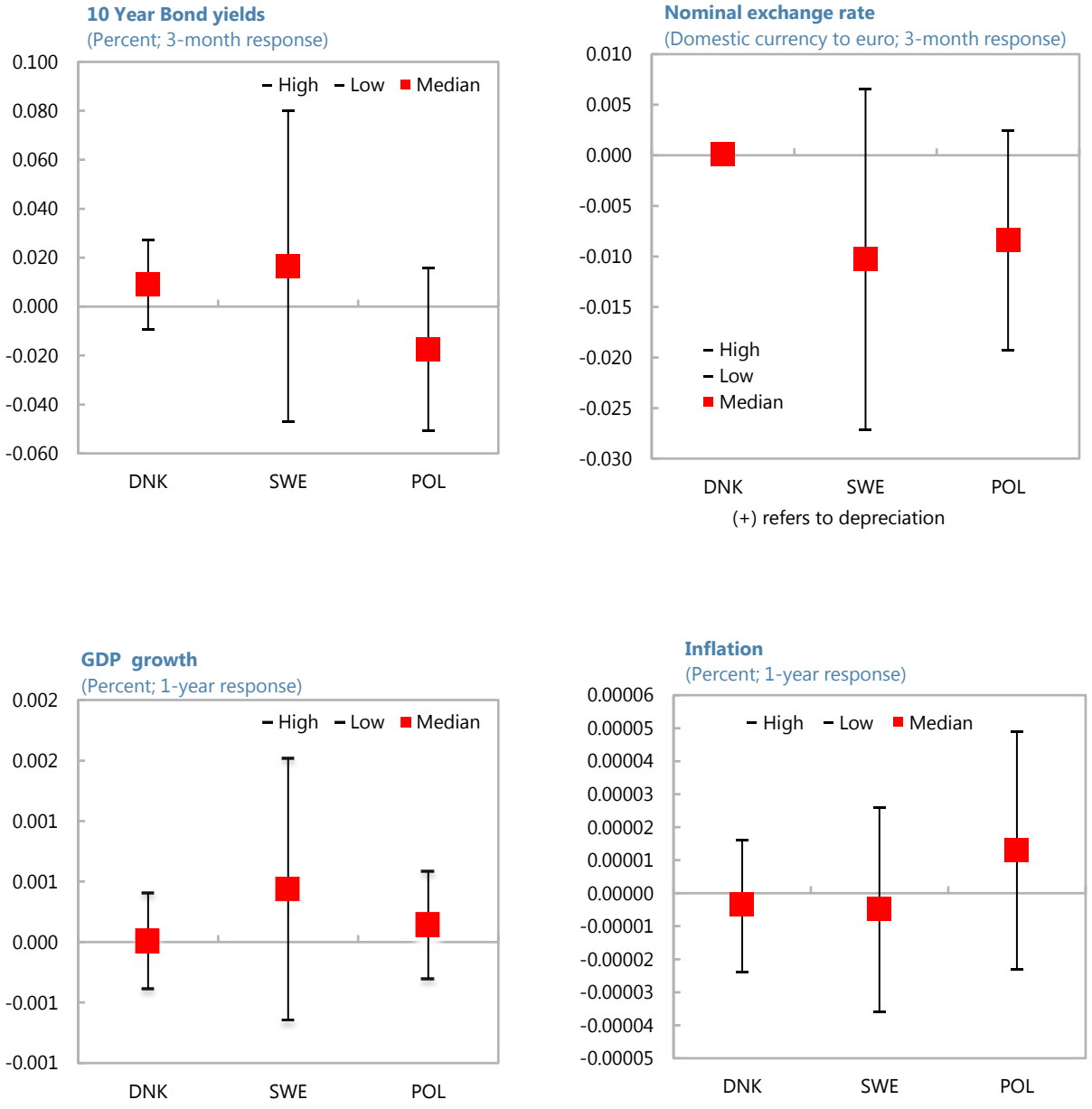


GDP growth
(Percent; 1-year response)



Source: IMF staff calculations.
[1] The 2 year bond yield is more appropriate to use in the case of Poland because interest rate transmission is largely seen through bond yields rather than interbank rates as they do not react to ECB QE.
[2] Each box represents the coefficient (labeled as median) while the high and low dashes represent a 95 percent confidence interval

Figure 4. Impulse-Reponses for Shock to ECB Security Holdings for Monetary Purposes[1]



Source: IMF staff calculations.

[1] Each box represents the coefficient (labeled as median) while the high and low dashes represent the 95 percent confidence interval.

Summary of Findings

29. The country level VAR analysis confirms earlier findings of ECB UMP spillovers through sovereign bond markets, and shocks to euro area term spreads appear to impact currencies, but there is no clear evidence of real spillovers. Shocks to euro area term spreads were found to have spillovers to domestic term spreads and policy rates even after controlling for factors likely to drive domestic monetary policies within the VAR. Polish and Swedish exchange rates generally move in the expected direction, and show statistical significance when term spreads are the indicator for ECB UMP. The limited spillovers to real sector variables are expected considering the short period of ECB UMP and are consistent with findings elsewhere in the literature. Research that finds significant spillovers onto real sector variables do so only in the medium term, e.g., after 18 months.[12]

E. A Global VAR Perspective on Spillovers

30. A global VAR (GVAR) framework allows an analysis of spillovers that coherently accounts for bilateral inter-relationships across countries. The key methodological contribution of the GVAR model of Pesaran and others (2004) is dealing with the curse of dimensionality, where the number of parameters to estimate grows rapidly with the number of countries in the model.[13] This is done by estimating country-specific models that include domestic variables as well as 'foreign' variables that are constructed as weighted averages of domestic variables across all countries. In the context of cross-country spillover analysis, the weights are chosen to reflect bilateral trade shares or financial sector exposure across countries (see Annex III for a technical discussion).

31. A number of recent studies use the GVAR methodology to estimate the impact of UMP on real and financial variables, with a range of results. Chen and others (2015a) study spillovers from UMP of the Fed, finding that monetary policy in emerging markets tends to loosen in response to falls in corporate or term spreads in the U.S.—where such spread falls are commonly found in the literature evaluating the impact of UMP of the Fed. However, the results are mixed with respect to currencies, especially in Emerging Asia, where some currencies appreciate while others depreciate. Chen and others (2015b) find that U.S. Fed UMP has a stronger domestic and cross-border impact than ECB UMP. An earlier analysis by Dees and others (2005) explores international linkages of the euro area using a GVAR framework, although their analysis naturally does not focus on UMP. They find that financial shocks are transmitted relatively rapidly between the U.S. and euro area, and that equity and bond prices are far more synchronized than real output, inflation,

[12] Tillmann (2014).

[13] The GVAR differs from the unrestricted VAR and panel VAR (PVAR) in a number of respects. Through the use of foreign variables, the GVAR is able to account for bilateral inter-relationships amongst countries, and therefore control for spillovers on the basis of cross-country exposure. Additionally, the use of foreign variables allows the GVAR to scale up in a coherent manner and include a larger number of variables than possible in a VAR. Unlike a PVAR model, a GVAR also maintains the capability of giving country-level estimates.

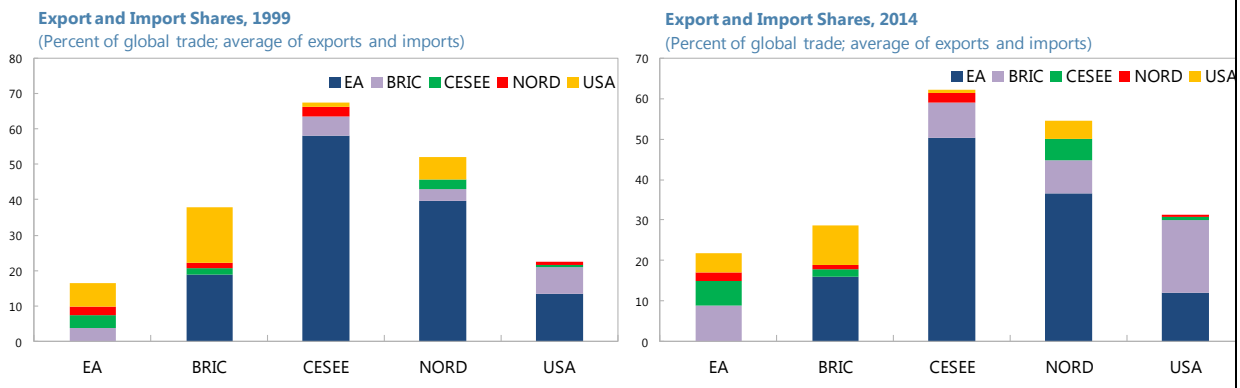
and short-term interest rates. Confidence intervals in these studies are wide and impacts are often not statistically significant.

32. The GVAR analysis presented in this section covers six small European countries together with their main trade and financial partners. The analysis focuses on CESEE countries (Czech Republic, Hungary, Poland, and Romania) and Nordic countries (Denmark and Sweden).These countries are embedded in a model with nine individual countries and two blocs of countries, that together account for 62 percent of global GDP on a PPP basis in 2014. The euro area bloc includes Austria, Belgium, France, Germany, Italy, the Netherlands, and Spain, comprising 87 percent of euro area GDP on a PPP basis. The BRIC bloc includes Brazil, Russia, India, and China. Other advanced economies included in the model are Switzerland, the United Kingdom, and the United States. These countries and blocs are selected as those with which the CESEE and Nordic countries under consideration have the strongest trade and financial linkages.

33. The model uses bilateral trade weights to capture linkages across countries. Bilateral trade relationships are chosen to model bilateral interdependencies across countries as they are an important source of inter-country business cycle linkages (see Baxter and Kouparitsas, 2004). CESEE and Nordic countries enjoy strong trade ties with the euro area. On average, close to 60 percent of CESEE export and import trade was with the euro area in the early 2000s, while close to 40 percent of Nordic export and import trade was with the euro area in that period.

34. While the euro area remains the largest trading partner for these countries, its relative share has declined over time as other regions, especially the BRICs, have grown in importance. Bilateral trade linkages between the United States and both the CESEE and Nordic countries are less significant. Within the model, time-varying trade weights are used to allow for this evolution in bilateral trade relationships. (Figure 5).

Figure 5. Trade Shares



Source: IMF staff calculations.

35. Shadow policy rates and the spread between short- and long-term government bond yields are used to represent the monetary stance including unconventional measures. Shadow rates are included for major central banks implementing unconventional measures: the U.S. Fed,

Bank of England, and ECB.[14] Additionally, an alternate analysis is performed using the spread between short-term and long-term government bond yields, where a decrease in the spread is taken as a proxy for the impact of unconventional policies. For model simulations, identification of structural monetary policy shocks within the euro area is done using a Cholesky decomposition.

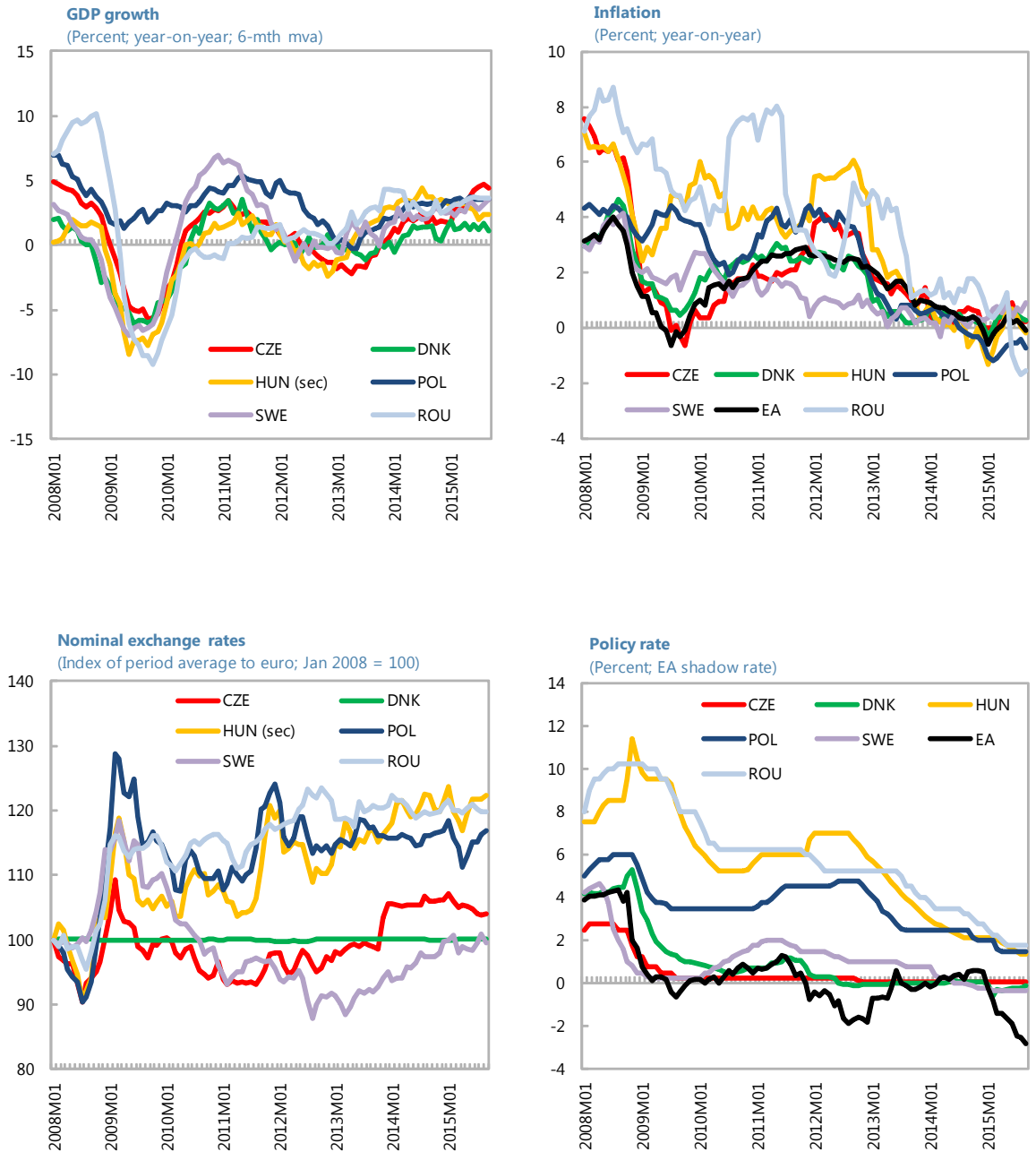
36. The effects of unconventional monetary policy shocks are examined based on simulations using structural and generalized impulse response functions. Estimation begins in 2008 to focus the analysis on the period during which unconventional policies have been in place. Country-specific vector error-correction models (VECMs) are estimated using real GDP, inflation, exchange rates relative to the euro, and a measure of the monetary stance (the shadow rate or spread between long-term and short-term treasury bond yields). Variables included in the model are illustrated in Figure 6. Global variables including the VIX and oil prices are used to control for financial sector volatility and the impact of declining oil prices. A monthly frequency is used for the data, where quarterly GDP data are interpolated into a monthly series.[15] Trade weights are used to generate weakly exogenous foreign variables, and the individual VECMs are stacked to the GVAR model.

37. UMP by the ECB is not found to have had a statistically significant impact on CESEE and Nordic economies, with the exchange rate closest to a significant response. A one standard error negative shock to the ECB shadow policy rate corresponds to a 30 basis point decrease in the shadow rate. A summary of the structural impulse response functions for this shock are provided in Figure 7. After three months, median estimates show a small decline in domestic policy rates for most countries, with a statistically significant fall in the Danish policy rate of 5 basis points. A positive relationship is expected given its euro peg. Nominal exchange rates appreciate relative to the euro after three months for most countries except Romania and the Switzerland, with the Swedish krona appreciating the most. After one year, median estimates of inflation and GDP growth responses show a small increase. An additional analysis tests the impact of a one standard error negative shock to the ECB shadow rate on 10-year bond yields, finding that median yields in most countries decline in the first month following the shock. Generally, impulse responses across variables are statistically insignificant due to wide confidence bands. For robustness, models were run using the short term interest rate and term spread, with similar results. Additionally, models were run with the real effective exchange rate and an exchange rate pressure index. Using quarterly data, models are also estimated over a longer period, beginning in 1999. A robustness analysis using a panel VAR is reported in Box 1.

[14] Wu-Xia shadow rates are used in the analysis.

[15] Monthly industrial production data are used to interpolate the quarterly GDP data using the Denton method.

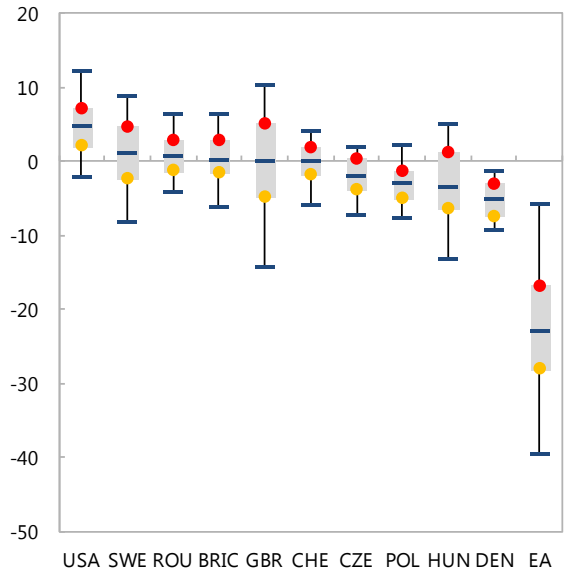
Figure 6. GVAR Variables



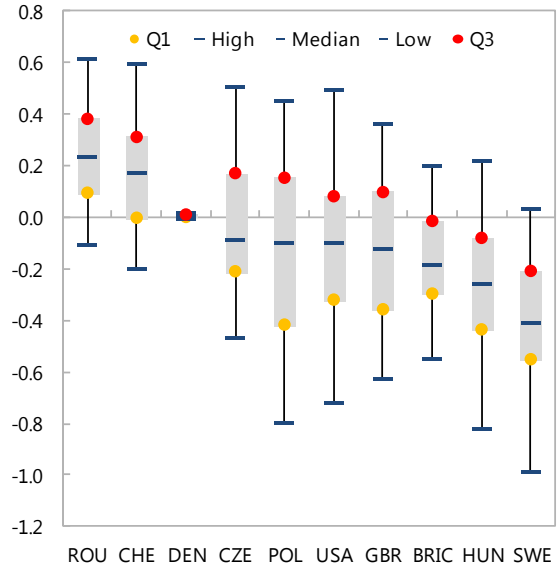
Source: Haver Analytics and IMF staff calculations.

Figure 7. Structural Impulse Response Functions

Policy (or shadow) rate
(Basis points; 3-month response)

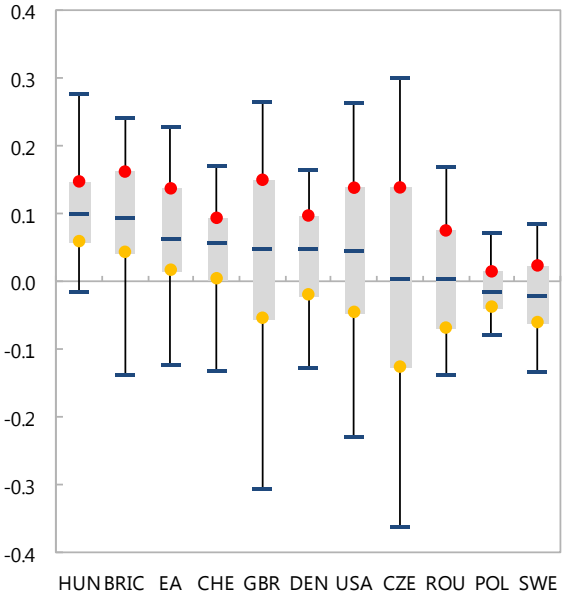


Nominal Exchange rate
(Percent; Domestic currency to 1 euro; 3-month response)

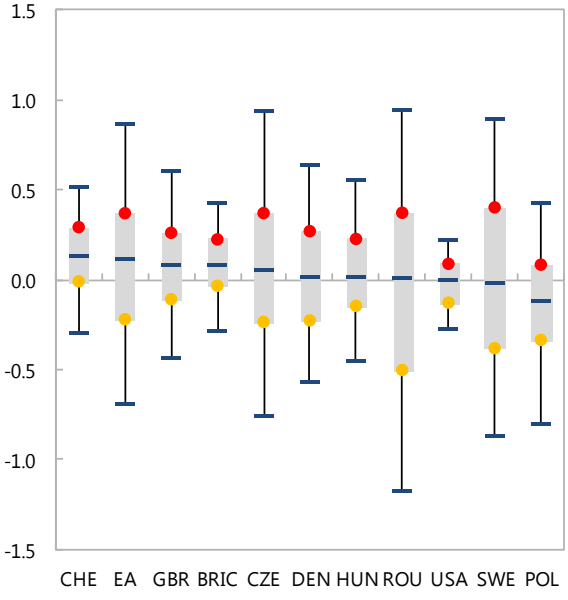


Note: (-) is currency appreciation.

Inflation
(Percent; one-year response)



GDP
(Percent; one-year response)



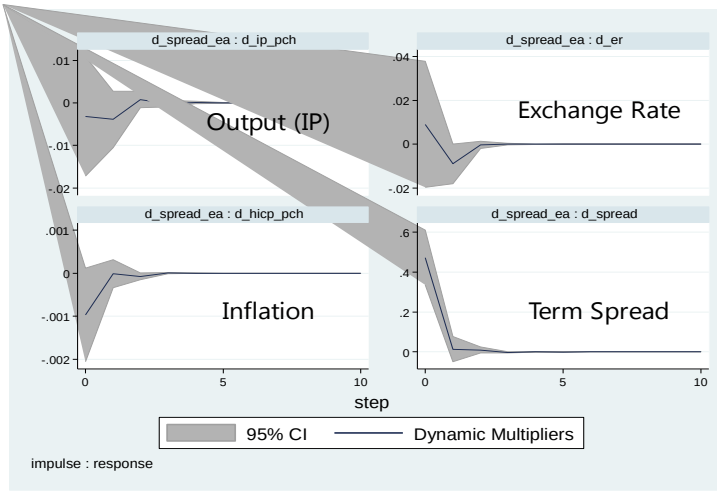
Source: IMF staff calculations. Q1 and Q3 of the boxplots represent the first and third quartiles, while the High and Low whiskers represent a 90 percent confidence interval.

Box 1. A Panel VAR Perspective on Spillovers

A panel VAR analysis is conducted as a robustness check for the country VAR and the GVAR. Following Abrigo and Love (2015), homogeneous panel VARs are estimated in a generalized method of moments framework, using consistent moment and model selection criteria (Andrews and Lu, 2001). Similar to the country VAR, the panel VAR simulates a shock from ECB policy on the non-euro area EU countries. The effect of UMP in the EA is captured using both a price and a quantity measure: the EA term spread (10-year government bond yield less three-month Euribor) and the ECB's purchases of securities. Potential spillovers onto the financial and real sectors in non EA countries are then assessed using four variables: the term spread, the exchange rate (an increase is a depreciation), inflation, and output.

Two sets of panel VAR analyses are considered. The first panel VAR replicates the individual country VAR analysis (Denmark, Poland, and Sweden) using 612 country-monthly observations over the period 1999–2015. In the second panel VAR, country coverage is broadened by considering the larger set of non-EA countries as in the GVAR system, with 268 country-quarter observations for countries with floating exchange rate regime (Hungary, Poland, Sweden, and the UK) and 201 country-quarter observations for other countries (Czech Republic, Denmark, and Switzerland) over the same period. The results from the first panel VAR are displayed in figure below, and those of the second panel VAR are in summarized in table below. All variables are first differenced.

Spillovers to Denmark, Poland, and Sweden: Response to a Shock to the EA Term Spread



Spillovers from the ECB's QE occur through both financial and real channels (see figure). Similar to the findings from the country-level VAR, a shock to EA term spreads spills over to domestic spreads in neighboring countries. An increase in EA term spreads by 1 percent raises domestic term spreads by 0.5 percent. The effect of higher term spreads on domestic inflation is negative albeit muted. Hence, a monetary policy easing in the form of compressed term spreads will have opposite effects, reducing domestic spreads and slightly raising inflation. We also explore the effect of an increase in ECB's holding of securities for monetary policy purposes on domestic financial and real variables but the findings are generally insignificant.

The strength of spillovers through the sovereign bond channel is similar across different exchange rate regimes (see table). Domestic spreads in non-EA countries narrow in response to narrowing of EA spreads. They are also reduced following increases of the holdings of securities by the ECB for monetary policy purposes (not reported) irrespective of the exchange rate regime. The effect on the exchange rate, however, has a counterintuitive sign.

Spillovers to Non-EA Countries: Response to a Shock to the EA Term Spread

	Exchange Rate Arrangement	
	Other*	Float**
Term Spreads	**Lasts for 2q**	**Lasts for 1q**
FX	*Lasts for 1q*	*Lasts for 1q*
Inflation	Insignificant	*Lasts for 1q*
Output	Insignificant	Insignificant

Bold (italics) indicates that effect is in line with (opposite to) expectation. *Czech Republic, Denmark, and Switzerland. **Hungary, Poland,

38. When interpreting the GVAR findings the evolving environment in which the ECB's UMP operations took place needs to be considered. Unconventional policies by the ECB were first aimed at addressing failures in monetary policy transmission owing to weaknesses in the euro area banking system and distress in sovereign bond markets. In this period, ECB balance sheet expansion was needed to meet liquidity demand, e.g., the breakdown of interbank funding markets. The underlying challenges began to be tackled from mid-2012, especially through President Draghi's commitment to do whatever it takes to preserve the euro and the agreement on a banking union which underpinned bank recapitalization ahead of the Single Supervisory Mechanism. In contrast, the more recent proactive steering of the ECB's balance sheet is a response to low inflation owing to weak growth over a number of years. These changing conditions make it challenging to estimate the impact of UMP by the ECB in this sample, and may account in part for the wide standard errors, making it difficult to find statistically significant spillovers.

F. Conclusion and Policy Implications

39. The analysis supports financial spillovers from ECB UMP to neighboring economies, with results in the expected direction, although not always statistically or economically significant. The summary of recent developments shows a high correlation of bond yields in these countries with those of the euro area, along with a significant appreciation of their currencies and some capital inflows as the ECB's adoption of APP approached. The more rigorous empirical analyses employing a range of methodologies generally support the strength of spillovers via sovereign bond markets. Evidence of the impact on exchange rates is found in the event study analysis, especially for more recent years, and also in the country VAR when ECB UMP is represented either by term spreads and ECB holdings of securities for monetary purposes. The GVAR provides additional support if not statistically significant. Consistent with much of the literature, evidence of real sector spillovers appears weak across these methodologies. Directional indicators of the impact of UMP on financial and real variables across models are summarized in Table 1 below.

Table 1. Direction of Median Impact of UMP on Real and Financial Sector Variables[1/2/3/]

	Event Study	Country VAR	Global VAR	Panel VAR
Policy rate	N/A	-	-	N/A
Government bond yields	-	-	-	N/A
Domestic term spread	N/A	-	-	-
Exchange rate	+	+	+	+
Equity returns	0	N/A	N/A	N/A
Inflation	N/A	+	+	+
GDP growth	N/A	-	0	+

Notes:

1/ Green indicates statistical significance and red otherwise. 'N/A' is used where a variable is not used in a given methodology and 0 where the median response of the variable is zero.
2/ Identification of UMP shocks is dependent on the model specification. The table shows the directional impact of variables to a negative UMP shock in the euro area (identified as a UMP announcement, a decrease in the shadow rate, or a compression of the term spread).
3/ Median responses differ across countries. Directions correspond to responses for the majority of countries.

40. Some inconclusive results do not mean that spillovers do not exist. The analyses in this paper may not completely capture spillover effects for a number of reasons: (i) difficulty in identifying the underlying shocks behind changes in monetary conditions, particularly in the VAR analysis; (ii) market anticipation of policy decisions prior to actual announcements by the ECB or Fed limiting the impact on actual announcement dates in the event study; (iii) the evolving nature of the ECB's UMP, as it first aimed at addressing failures in monetary policy transmission, and more recently has been tackling low inflation and growth; and (iv) domestic monetary policy responses to actual or anticipated ECB actions with a view to limiting spillovers.

41. UMP in the euro area may be prolonged so there is potential for vulnerabilities to build. Bond yields that are lower than otherwise would be the case will ease government debt servicing costs over time, reduce the cost of credit, and provide a near-term boost to growth. Yet, they may also drive up domestic asset prices and stimulate excessive credit expansion to the private sector, such as corporate debt issuance, as experienced by some emerging markets in the context of Fed QE. Aside from Sweden, credit growth remains low or moderate among these countries, but needs to be monitored closely. Appreciating exchange rates may shift more activity into the non-tradable sector, weakening the external position over time. A buildup of such vulnerabilities would make for a more difficult adjustment when ECB policies normalize. Such an environment risks financial market volatility, akin to the spring 2013 "taper tantrum" and the further bout of volatility in early 2016 associated with the withdrawal of stimulus by the Fed.

42. A number of these countries have already adopted policies that will help protect growth and stability:

- In the Czech Republic, the authorities implemented an exchange rate floor as an additional instrument of monetary policy to help lift inflation (Alichi and others, 2015). 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.

- Denmark introduced negative policy rates and effectively implemented its own QE by suspending government bond issuance, countering pressures on the peg that underpins price stability. As these pressures have eased issuance was resumed and the spread between the Danish and ECB policy rates was narrowed.

- Hungary has in recent years gradually reduced the policy rate, lowered and narrowed the interest rate corridor, and effectively reduced reserve requirements. Collateral requirements for central bank lending facilities were also adjusted. Effective March 23, 2016, the overnight deposit rate was reduced from 0.10 percent to -0.05 percent. Finally, macro-prudential tools have been strengthened (loan-to-value ratios) or introduced (payment-to-income ratios), and most foreign-currency denominated mortgages and personal loans have been converted to local currency, with a view to preventing un-hedged borrowers facing FX risks.

- Poland lowered the main policy interest rate by 100 basis points cumulatively between October 2014 and March 2015. In parallel, macroprudential policies have been gradually strengthened, including by lowering loan-to-value limits. The authorities have also recently completed a macroprudential framework, which allows for early detection and prevention of systemic risk.

- Sweden introduced negative policy rates and implemented QE in early 2015 in order to lift inflation, partially in anticipation of further ECB action. The Riksbank has also signaled scope for foreign exchange intervention if needed to ensure a continued increase in inflation. Building on earlier macroprudential steps, the Swedish financial supervisor is in the process of adopting mortgage amortization requirements to moderate household vulnerabilities over time.

43. Going forward, policymakers should stand ready to adapt macroeconomic and prudential policies further to safeguard stability. Easing of domestic monetary policy, may, in the process of supporting domestic inflation objectives, also help moderate spillovers on the exchange rate. Yet, in some cases monetary policy now has less space for additional expansion, so the tools available to address vulnerabilities may be more restricted. In particular, tightening fiscal policy to lean against real exchange rate appreciation may not be effective when there is little room to lower domestic interest rates. Other exchange rate policy options, including foreign exchange intervention and capital flow measures, may need to be considered if pressures are strong. The appropriate response will need careful evaluation depending on country-specific circumstances including an assessment of the exchange rate level, the monetary-fiscal policy mix and space including for domestic UMP, the time horizon, and financial stability and credibility concerns (IMF, 2012). At the same time, while policies should focus on supporting domestic economic stability, policymakers should be mindful of limiting any adverse external spillovers. Macroprudential instruments could have a large role to play in protecting the financial resilience of the corporate and household sectors, especially if a low interest rate environment is prolonged, thereby preserving financial stability when interest rates eventually rise.[16]

[16] For example, Turk (2015) finds low interest rates have a significant positive effect on Swedish house prices. Together, low interest rates and high house prices drive up the share of households who are highly indebted. A limit on household loan-to-income ratios—as recently adopted in the U.K. and Ireland—is a potential instrument to contain vulnerabilities, including to an increase in interest rates. Chen and Columba (2016) find that demand side macroprudential measures (loan-to-value ratios, amortization requirements, and tax deductibility of mortgage interest payments) are more effective in curbing household debt ratios than monetary policy.

Annex I. Event-Study Approach

Benchmark Regressions: Time series regressions are run separately for individual financial variable and country. The financial variables are the dependent variables, which include 10-year bond yields, equity returns, nominal effective exchange rates, bilateral exchange rate vs. USD, and mutual fund equity/bond flows. On the right hand side, in addition to the dummy variable that captures ECB APP announcement date, the regression controls for domestic monetary policy rate changes, ECB policy rate changes, IMF/EC programs events, and European equity market volatility. This would yield abnormal changes on financial variables led by APP announcement after netting out the effect from the controls.

$$\Delta F_{it} = \alpha + \beta_1 ECB_{it} + \gamma_1 VIXeuro_{it} + \gamma_2 \Delta PRdomestic_{it} + \gamma_3 FEDtaper_{it} + \gamma_4 FEDQEs_{it} + \gamma_5 EApr_{it} + \gamma_6 Programs_{it} + \varepsilon_t$$

Where:

Fs are financial variables
ECB is a dummy on the days of UMP announcements
VIXeuro is the volatility index on European equity market
PRdomestic is domestic policy rate changes
FEDtaper is a dummy on the days of FED taper news
FEDQEs is a dummy on the days of FED QE announcements
EApr captures euro area policy rate changes

On the equity returns regression, U.S. equity returns are also controlled for. For the asset price regressions, we choose to look at two-day windows following the events, which is more frequently used in the event study literature. Capital flow data is only available at weekly frequency; hence we construct weekly announcement indices by averaging the dummy variables. For example, if there are two days of announcements in a week, the week's variable would show as 2/7. Weekly event studies may not work as well as daily ones as immediate market reaction may reverse over a longer time horizon. Hence, we should interpret the results with caution.

Direct and Indirect Impact: ECB UMPs can have both direct and indirect impact on asset prices. While the coefficient on APP announcement (β_1) captures direct impact, the estimation of indirect impact requires two stages of regressions. In the first stage, VIX is regressed on ECB APP dummy.

$$VIXeuro_{it} = \alpha + \beta ECB_{it} + \varepsilon_t$$

In the second stage, the residual ε_t which reflects VIX that is not affected by ECB APP, is used as the independent variable replacing VIX in benchmark regression. We rename ε_t as VIXeuropurged

$\Delta F_{it} = \alpha + \beta_2 ECB_{it} + \gamma_{12} VIXeuropurged_{it} + \gamma_{22} \Delta PRdomestic_{it} + \gamma_{32} FEDtaper_{it} + \gamma_{42} FEDQEs_{it} + \gamma_{52} EApr_{it} + \gamma_{62} Programs_{it} + \varepsilon_t$

The difference between $\beta_1$and β_2 captures the indirect impact.

Rolling Regressions: Rolling regressions are conducted on a 180 days window or 30 weeks in the case of capital flow regressions to see how spillover has evolved over time. The model specification remains the same as static benchmark regressions. Annual coefficients are the average of the rolling coefficients of the year.

Robustness Checks: Robustness checks were carried out using three-day and one-day windows, and controlling for lagged VIX to capture the unwinding of the built-up of uncertainty in the run-up to ECB announcements. The results remain broadly robust.

Table A1.1. Spillover Effect on 10-year Sovereign Bond Yields

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	-0.0210***	-0.0202***	-0.0200***	-0.0326**	-0.0386**	-0.0384**	-0.0232***	-0.0249***	-0.0246***	-0.0149***	-0.0124**	-0.0118**	-0.0184***	-0.0165***	-0.0160**
	0.0063	*0.0065*	*0.0065*	*0.0165*	*0.0168*	*0.0168*	*0.0067*	*0.0068*	*0.0068*	*0.0056*	*0.0059*	*0.0059*	*0.0062*	*0.0063*	*0.0063*
VIXeuro	-0.0005**			0.0051***			0.0014***			-0.0026***			-0.0020***		
	0.0002			*0.0006*			*0.0002*			*0.0002*			*0.0002*		
PRdomestic	0.0897			0.0064			-0.0656			-0.0084					
	0.0596			*0.0522*			*0.0461*			*0.0299*					
FedQE	0.0116		0.0127	0.1399**		0.1345**	0.0211		0.0233	-0.0539***		-0.0519***	-0.0582***		-0.0566**
	0.0195		*0.0201*	*0.0512*		*0.052*	*0.0211*		*0.0211*	*0.0176*		*0.0182*	*0.0192*		*0.0195*
FedTaper	0.0911***		0.0894***	0.1232		0.1467*	0.1216***		0.1280***	0.0459		0.0344	0.0371		0.0278
	0.0337		*0.0348*	*0.0885*		*0.0899*	*0.0362*		*0.0365*	*0.0304*		*0.0315*	*0.0332*		*0.0337*
EApr	-0.0145		-0.0165	-0.2409**		-0.2306	-0.0594		-0.0577	-0.038		-0.0461	-0.0257		-0.0281
	0.0459		*0.0474*	*0.1206*		*0.1225*	*0.0494*		*0.0498*	*0.0452*		*0.043*	*0.0452*		*0.0461*
Program				-0.03			-0.0302								
				0.0297			*0.0362*								
# of observations	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024
Adj R^2	0.0099	0.0042	0.0082	0.04	0.0021	0.0069	0.0272	0.006	0.0118	0.0767	0.0017	0.0054	0.044	0.0029	0.0061

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.2a. Spillover Effect on Nominal Effective Exchange Rates

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	0.0025	-0.0125	-0.012	-0.0223	-0.0701	-0.0678	-0.0379	-0.0744	-0.0771	-0.0004	-0.0311	-0.0346	-0.0035	-0.0257	-0.0271
	0.054	*0.0544*	*0.0544*	*0.0828*	*0.0859*	*0.0858*	*0.0815*	*0.0847*	*0.0847*	*0.0904*	*0.092*	*0.092*	*0.2031*	*0.203*	*0.2032*
VIXeuro	0.0129***			0.0379***			0.0378***			0.0294***			0.0206***		
	0.0019			*0.003*			*0.0029*			*0.0033*			*0.0074*		
PRdomestic	-0.0796			-0.3367			-1.2803**			0.394					
	0.5092			*0.261*			*0.553*			*0.4747*					
FedQE	0.2063		0.1963	0.3688		0.3533	0.5856**		0.6211*	0.5303*		0.5082*	0.3267		0.3111
	0.1667		*0.1683*	*0.2559*		*0.2654*	*0.2531*		*0.2619*	*0.2792*		*0.2846*	*0.6271*		*0.6281*
FedTaper	-0.0059		0.0528	0.7425*		0.9262*	0.4069		0.5798	-0.0464		0.0678	0.1836		0.2774
	0.2881		*0.2908*	*0.4421*		*0.4585*	*0.435*		*0.4524*	*0.4832*		*0.4917*	*1.0839*		*1.0852*
EApr	-0.6493*		-0.6341	-0.8194		-0.7825	0.1735		0.216	-0.0635		0.2079	0.0672		0.091
	0.3925		*0.3965*	*0.6026*		*0.6251*	*0.5928*		*0.6168*	*0.7172*		*0.6703*	*1.477*		*1.4794*
Program				0.0601			-0.8709**								
				0.1484			*0.435*								
# of observations	2024			2024			2024			2024			2024		
Adj R^2	0.02	-0.0005	-0.0001	0.074	-0.0002	0.0001	0.078	-0.0001	0.002	0.037	-0.0004	-0.0003	0.0015	-0.0005	-0.0001

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.2b. Spillover Effect on Exchange Rates vs. Euro

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	-0.0263	-0.0392	-0.0388	-0.0386	-0.0851	-0.083	-0.0801	-0.1124	-0.1156	-0.0257	-0.0460	-0.0473	0.0016	0.0018	0.0018
	0.0507	*0.0509*	*0.0509*	*0.0767*	*0.0795*	*0.0794*	*0.0737*	*0.0765*	*0.0763*	*0.0583*	*0.0593*	*0.0591*	*0.0018*	*0.0018*	*0.0018*
VIXeuro	0.0107***			0.0347***			0.0336***			0.0176***			-0.0001		
	0.0018			*0.0027*			*0.0026*			*0.0021*			*0.0001*		
PRdomestic	0.0962			-0.7729**			-0.9461*			0.1548					
	0.4785			*0.2417*			*0.5004*			*0.3063*					
FedQE	0.2083		0.2005	0.4107*		0.4131*	0.7012***		0.7231***	0.6577***		0.6433***	-0.0072		-0.0071
	0.1566		*0.1575*	*0.237*		*0.2455*	*0.2291*		*0.2361*	*0.1801*		*0.1829*	*0.0057*		*0.0057*
FedTaper	-0.0823		-0.0333	0.6585		0.8434**	0.2832		0.4368	0.2846		0.3558	-0.0045		-0.0049
	0.2707		*0.2720*	*0.4094*		*0.4242*	*0.3936*		*0.4079*	*0.3117*		*0.316*	*0.0098*		*0.0098*
EApr	-0.6569*		-0.6449*	-0.9404*		-0.9106	-0.004			-0.7566			0.0122		0.0121
	0.3688		*0.3709*	*0.5581*		*0.5783*	*0.5364*			*0.4627*			*0.0134*		*0.0134*
Program				0.093			-0.8183**								
				0.1374			*0.3936*								
# of observations	2024			2024			2024			2024			2024		
Adj R^2	0.0161	-0.0002	0.0006	0.0765	0.0001	0.0031	0.0773	0.0006	0.0042	0.0379	-0.0002	0.0026	0.0001	0.0005	-0.0002

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.3. Spillover Effect on Equity Returns

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	-0.3455**	-0.1152	-0.2812*	-0.2249	0.0012	-0.1638	-0.0907	0.0972	-0.0392	-0.1951*	0.0464	-0.1327	-0.2572**	-0.0560	-0.1978
	0.1561	*0.1918*	*0.1618*	*0.1752*	*0.2067*	*0.1793*	*0.1291*	*0.1594*	*0.1332*	*0.1139*	*0.1702*	*0.1214*	*0.1151*	*0.1557*	*0.1218*
VIXeuro	-0.0754***			-0.0675***			-0.0576***			-0.0727***			-0.0690***		
	0.0059			*0.0067*			*0.0049*			*0.0043*			*0.0044*		
PRdomestic	0.1879			0.3157			-0.5716			0.1815					
	1.4745			*0.5521*			*0.8769*			*0.5983*					
FedQE	0.0034		0.1465	0.6579		0.7826	-0.2195		-0.0828	0.0481		0.1855	0.0792		0.2096
	0.4822		*0.5004*	*0.5419*		*0.5545*	*0.4012*		*0.4120*	*0.3523*		*0.3754*	0.3559		*0.3766*
FedTaper	-0.5341		-0.8524	-0.1733		-0.474	-0.172		-0.4157	-0.2423		-0.5582	0.9142		0.6228
	0.8325		*0.8638*	*0.935*		*0.9571*	*0.6889*		*0.7111*	*0.609*		*0.648*	*0.6145*		*0.6501*
USEq	0.5592***		0.6525***	*0.5785****		*0.6615****	*0.4895****		*0.5598****	*0.6792****		*0.7689****	0.5406***		*0.6258****
	0.0235		*0.0231*	*0.0264*		*0.0256*	*0.0195*		*0.019*	*0.0171*		*0.0173*	*0.0173*		*0.0174*
EApr	6.7374***		6.6524***	4.4304***		4.3291***	4.2573***		4.1924***	1.7102*		1.7381*	*0.9179*		0.8405
	1.1344		*1.1776*	*1.2746*		*1.3047*	*0.9388*		*0.9694*	*0.9038*		*0.8834*	*0.8373*		*0.8863*
Program				0.1619			-0.2978								
				0.3139			*0.6895*								
# of observations	2024			2024			2024			2024	2024	2024	2024	2024	2024
Adj R^2	0.3402	-0.0030	0.2889	0.2869	-0.005	0.2488	0.3459	-0.0030	0.3025	0.4951	0.0050	0.4918	0.4541	-0.0040	0.3885

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.4. Spillover Effect on Equity Flows

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	0.0344	0.0194	0.0296	0.0610	0.0504	0.0546	-0.0597	-0.0838	-0.0741	-0.1392*	-0.1463*	-0.1450*	-0.1142	-0.1313*	-0.1217
	0.1031	*0.1049*	*0.1055*	*0.1202*	*0.1232*	*0.1237*	*0.1301*	*0.1315*	*0.1325*	*0.0782*	*0.0791*	*0.0801*	*0.0729*	*0.0745*	*0.0753*
VIXeuro	-0.0070***			-0.0083***			-0.0078***			-0.0055***			-0.0057***		
	0.0015			*0.0018*			*0.0019*			*0.0012*			*0.0011*		
PRdomestic	1.6973			-1.4707***			-0.9052			0.3709					
	1.3756			*0.5298*			*1.2441*			*0.5736*					
FedQE	-0.5731		-0.4724	-0.9114*		-0.7196	-0.6319		-0.4394	-0.0724		0.0326	-0.0862		0.0298
	0.4271		*0.4350*	*0.4963*		*0.5101*	*0.5406*		*0.5460*	*0.3231*		*0.3302*	0.3012		*0.3103*
FedTaper	-1.4524*		-1.4730*	-2.1385**		-2.1321**	-1.7179**		-1.7812*	-0.1593		-0.2041	0.7000		0.6715
	0.7731		*0.7915*	*0.9012*		*0.9281*	*0.9744*		*0.9934*	*0.5868*		*0.6008*	*0.5465*		*0.5645*
EApr	0.9741		1.0814	0.4599		0.3518	1.2578		1.3035	0.0925		0.3526	*0.5980*		0.6361
	1.0625		*1.0868*	*1.2382*		*1.2743*	*1.3384*		*1.3641*	*0.8762*		*0.8250*	*0.7504*		*0.7752*
Program				-0.0537			1.2917								
				0.2719			*0.9773*								
# of observations	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024
Adj R^2	0.0499	-0.0024	0.0037	0.0666	-0.0021	0.0083	0.0477	-0.0015	0.0026	0.0840	0.0085	0.0093	0.0657	0.0077	0.0030

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.5. Spillover Effect on Bond Flows

	Czech Republic			Hungary			Poland			Sweden			Denmark		
ECB	0.2365	0.1792	0.2369	0.2367	0.1302	0.2529	0.2537	0.1444	0.2330	0.1061	0.0705	0.1135	0.1421	0.0956	0.1402
	0.1758	*0.1761*	*0.1756*	*0.1943*	*0.2055*	*0.1985*	*0.1651*	*0.1699*	*0.1655*	*0.1648*	*0.1641*	*0.1652*	*0.1355*	*0.1359*	*0.1354*
VIXeuro	-0.0032			-0.0071**			-0.0051**			-0.0007			-0.0014		
	0.0027			*0.0029*			*0.0024*			*0.0024*			*0.0020*		
PRdomestic	1.8056			-2.6811***			1.5449			2.4906**					
	2.3432			*0.8564*			*1.5776*			*1.2089*					
FedQE	-0.7207		-0.6986	-1.1788		-1.0130	-0.5654		-0.5556	-1.2758*		-1.2967*	-0.7192		-0.6894
	0.7275		*0.7236*	*0.8023*		*0.8182*	*0.6855*		*0.6820*	*0.6811*		*0.6810*	0.5598		*0.5579*
FedTaper	-1.7548		-1.7557	-2.1593		-1.9902	-1.5754		-1.6132	-0.0670		-0.1889	-1.5306		-1.5380
	1.3168		*1.3166*	*1.4566*		*1.4887*	*1.2357*		*1.2409*	*1.2368*		*1.2392*	*1.0158*		*1.0152*
EApr	5.7961		5.8823	12.5182***		12.3622	9.3128***		9.4174	0.4481		1.9572	*4.3544****		4.3642
	1.8099		*1.8077*	*2.0015*		*2.0441*	*1.6973*		*1.7038*	*1.8469*		*1.7014*	*1.3948*		*1.3939*
Program				-1.0740**			1.3223								
				0.4395			*1.2393*								
# of observations	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024	2024
Adj R^2	0.0244	0.0001	0.0244	0.1224	-0.0015	0.0818	0.076	-0.0007	0.068	0.0084	-0.002	0.0025	0.0225	-0.001	0.0237

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.6. Rolling Regression Coefficients: 10 year Sovereign Bond Yields

	2008	2009	2010	2011	2012	2013	2014	201
Czech Republic	-2.44	-1.84	-1.31	-4.09***	-1.59	-0.63	-1.84	-8.07*
Hungary	-2.00	-4.08	-2.88	-4.22	-7.65**	-5.19	-6.65	-22.41**
Poland	-3.07	-3.07**	-2.70**	-0.4	-1.54	-3.44	-4.76*	-12.82*
Sweden	-2.05	-2.31	-0.03	-3.54	3.88	-1.06	-2.39***	-4.06
Denmark	-2.81	-4.07***	-0.61	-1.87	2.68	-1.07	-3.29***	-6.26

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.7a. Rolling Regression Coefficients: Nominal Effective Exchange Rates

	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	-0.08	-0.02	-0.13	-0.16	-0.16*	0.56	-0.01	0.08
Hungary	0.08	-0.18	0.1	-0.15	-0.11	-0.15	-0.29*	-0.38
Poland	0.23	0.14	-0.52*	-0.22*	-0.48*	-0.1	-0.19	-0.71*
Sweden	0.05	0.01	-0.1	0	0.12	-0.06	-0.27	-1.4
Denmark	0.07	0.08	-0.15	0.04	-0.06	-0.16	-0.08	-0.46

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.7b. Rolling Regression Coefficients: Exchange Rates vs. Euro

	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	-0.12	-0.08	-0.15**	-0.18	-0.17*	0.55	-0.06	-0.19
Hungary	0.08	-0.21	-0.01	-0.15	-0.12	-0.13	-0.36**	-0.64*
Poland	0.18	0.06	-0.57**	-0.24	-0.48***	-0.10	-0.32*	-1.19***
Sweden	0.04	0.02	-0.35*	-0.01	0.06	-0.19	-0.22	-0.85**
Denmark	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.05

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.8. Rolling Regression Coefficients: Equity Returns

	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	-0.02	-0.02	-0.01	-0.04	-0.02	-0.01	-0.02	-0.08
Hungary	-0.14	0.49	1.26	-0.88	0.22	-0.14	0.55	0.89
Poland	-0.05	0.05	0.77	-0.48	0.84	0.11	0.12	0.39
Sweden	-0.17	-0.44	0.79	-0.41	0.45	0.11	0.13	1.00
Denmark	-0.33	-0.65	0.87	-0.13	0.37	0.27	0.20	1.11

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.9. Rolling Regression Coefficients: Bond Flows

	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	-0.31	-1.21	-0.27	0.23	-0.15	0.49	0.34	0.29
Hungary	-0.56	-0.19	-0.44	0.27	0.05	0.34	-0.17	-0.04
Poland	-0.39	0.20	-0.51	0.13	0.02	0.37	-0.11	0.17
Sweden	-0.62	-0.21	-0.77	0.10	0.03	-0.28	-0.25	0.24
Denmark	-0.17	0.02	-0.84	0.10	0.03	0.01	-0.12	-0.82

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Table A1.10. Rolling Regression Coefficients: Equity Flows

	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic	0.01	-0.04	0.33	-0.11	0.00	0.52	0.04	0
Hungary	0.17	0.04	0.39	-0.16	0.07	0.68**	-0.01	0.04*
Poland	0.14	-0.10	0.07	-0.08	-0.02	0.01	-0.12	-0.14**
Sweden	0.29	-0.43	-0.10	-0.20	0.12	0.02	-0.08	0.12
Denmark	0.21	-0.13	0.05	-0.11	-0.13	0.03	-0.04	0.06

Sources: Haver Analytics, Bloomberg, and IMF staff calculations.

Annex II. Country VARs

A standard VAR is applied and estimated separately for each of the three economies. Each country specific VAR contains domestic variables on the endogenous side and euro area variables on the exogenous side as a block. The domestic variables are ordered starting with the country policy rate, followed by the exchange rate, inflation, and finally interpolated monthly GDP. The exogenous block comprises the variable representing ECB UMP (the euro area shadow rate, the term spread, and ECBs holdings of securities for monetary policy purposes), euro area interpolated monthly GDP, and the euro area inflation rate. A different ordering of the variables does not change the results.

For each country VAR the shock is applied to the euro area policy variable in the exogenous block. Specifically, the shocks are applied as a one standard deviation to the (i) euro area shadow rate, (ii) the term spread, and (iii) ECBs holdings of securities for monetary policy purposes. For each of the three specifications, the domestic variables included on the endogenous side are:

- For specifications (i) and (iii): ten-year bond yield, exchange rate, inflation, and interpolated monthly GDP;
- For specification (ii): short term rate, domestic spread, exchange rate, inflation, and interpolated monthly GDP.

The data are monthly from January 2002 to October 2015. GDP monthly numbers are interpolated. GDP and inflation are logged and expressed in terms of yearly percent change. The variable representing ECB security holdings for monetary purposes is logged. The remaining variables are first differenced in order to ensure that they are stationary. The VAR models are estimated with two and four lags for Denmark and two and three lags for Poland and Sweden. The lags were chosen per the lag selection criteria.

A robustness check was conducted using data starting in 2008 as well as industrial production instead of interpolated monthly GDP, and the results are broadly consistent.

Lastly, it should be noted that standard VARs may face challenges in the identification, particularly when the model includes financial variables. Even though shocks from a large economy could be treated as exogenous for a small economy, the results may reflect responses to other common factors which cannot be captured by the VAR. In addition, the sample period covers both conventional and unconventional monetary policy regimes.

Annex III. GVAR Model

Country-specific VAR* models are given by:

$$x_{it} = \Phi x_{i,t-1} + \Lambda_{i0} x_{it}^{*} + \Lambda_{i1} x_{i,t-1}^{*} + u_{it}$$

where: *x* is a vector of endogenous domestic variables and *x** is a vector of foreign variables calculated using some given weights (for example trade or financial flows data). Weights are calculated as:

$$x_{i,t}^{*} = \sum_{j=0}^{N} W_{ij} x_{jt} = W_i x_t$$

The VAR* models are estimated in error correction form using reduced rank regression estimation, and thereafter combined into a global model.

$$\Delta x_{it} = \alpha_i (\beta_{ix}^{'} x_{i,t-1} + \beta_{ix}^{'} x_{it-1}^{*}) + \Lambda_{i0} \Delta x_{i,t-1}^{*} + u_{it}$$

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