Online Appendix to
Monetary Dilemmas in the West African Union

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This version: May 25, 2026

Abstract

This online appendix contains additional results and materials for the paper 'Monetary Dilemmas in the West African Union.'

Keywords: Monetary policy, Monetary Union, Trilemma, Exchange Rates.
JEL Classification: E5, F3, F4, C3.

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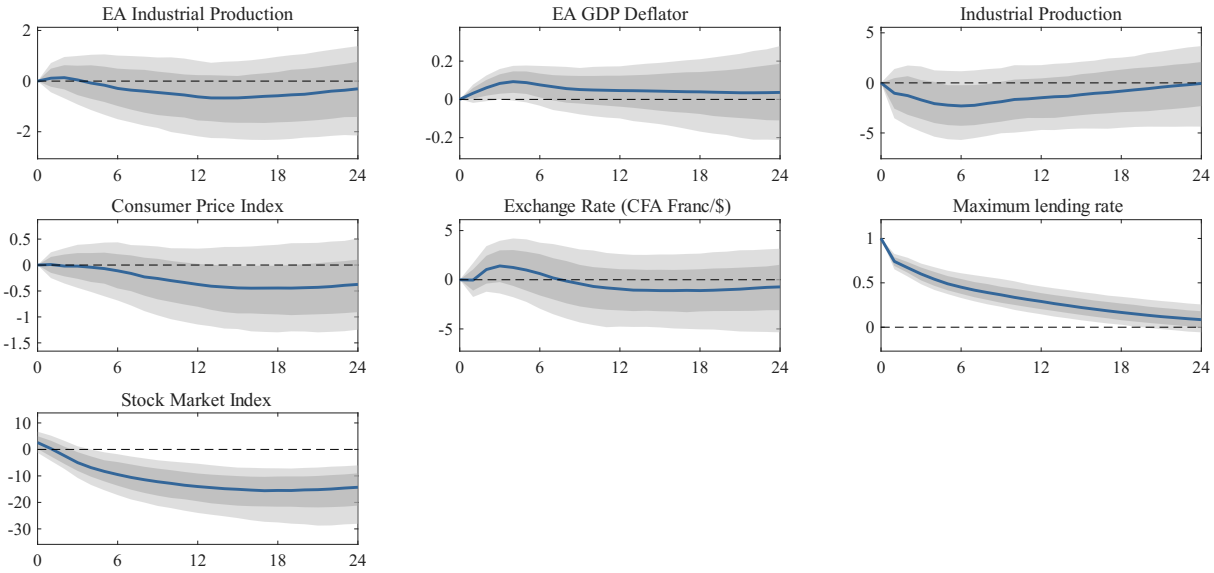
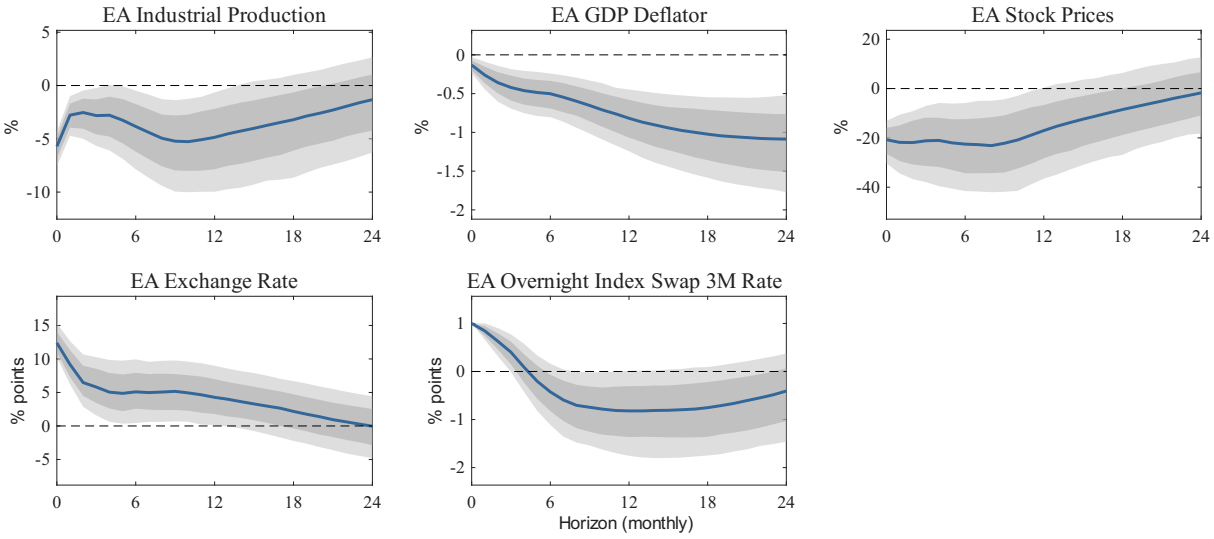


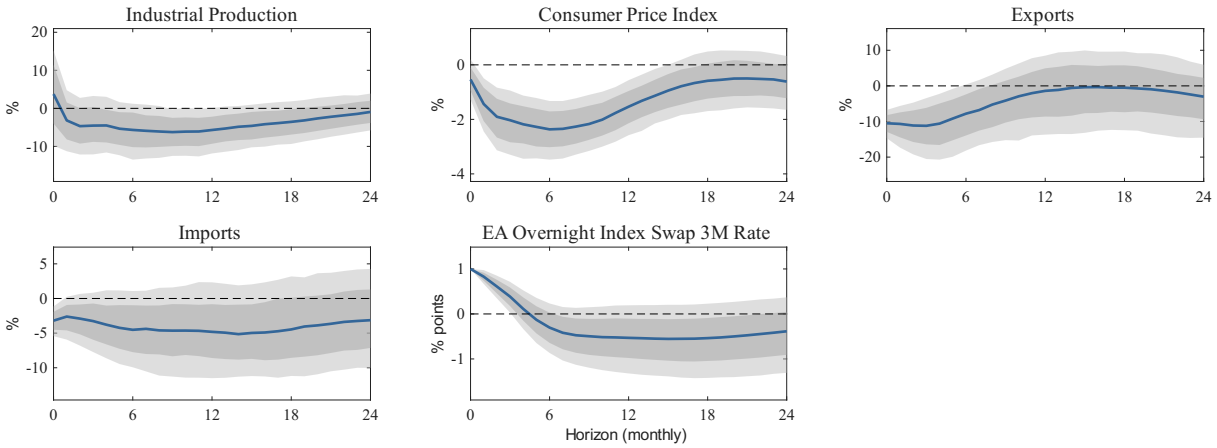
Note: WAEMU impulse responses to a 100 basis point contractionary monetary policy shock. Shaded areas are 68% and 90% posterior coverage bands. Sample 2002:01-2019:12.

Figure II: Conventional monetary policy in the euro area



Note: Euro area impulse responses to a conventional monetary policy shock, normalised to induce a 100 basis point increase in the three-month OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2002:01-2019:12.

Figure III: Euro area conventional monetary policy on WAEMU



Note: The figure reports the WAEMU impulse responses to a conventional monetary policy shock, normalised to induce a 100 basis point increase in the three-month OIS rate, and obtained using country-level data. Shaded areas denote the 68% and 90% posterior coverage bands. Sample: 2002:01-2019:12.

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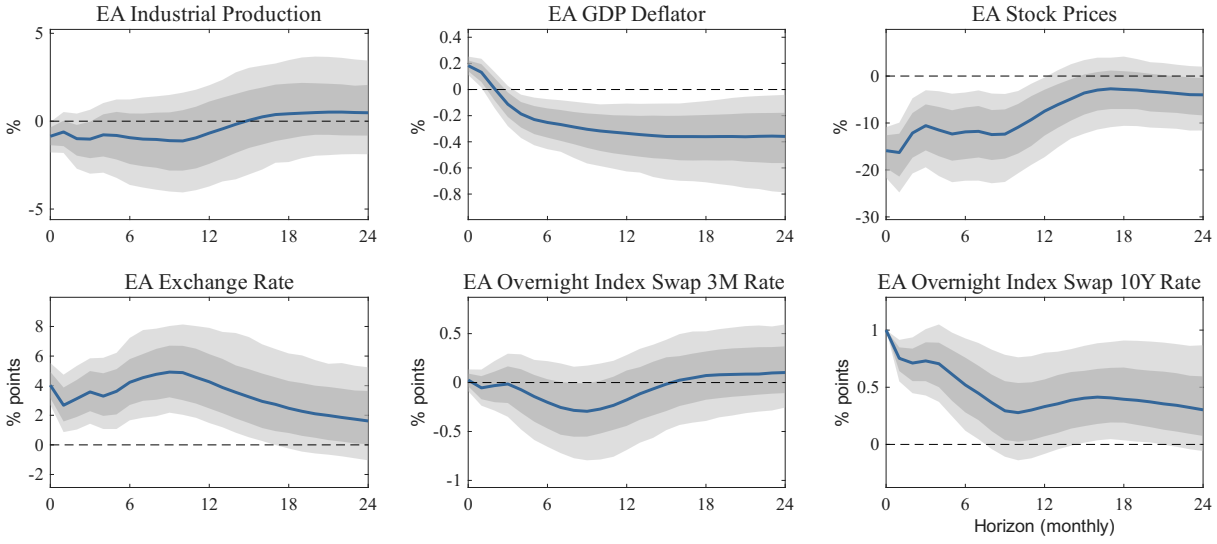

Note: The figure reports the impulse responses to an unconventional monetary policy shock in the euro area, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2008:01-2019:12.

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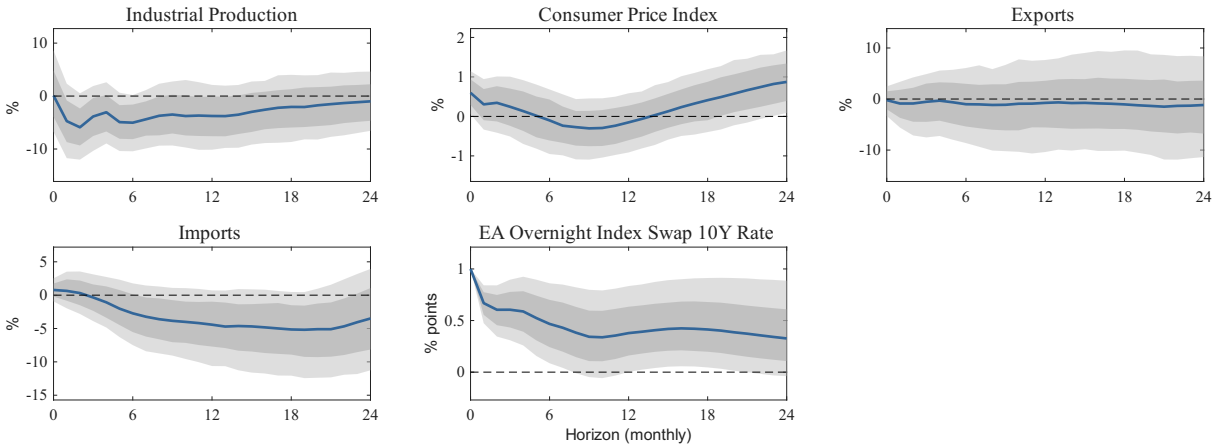

Note: The figure reports the WAEMU impulse responses to an unconventional monetary policy shock in the euro area, normalised to induce a 100 basis point increase in the ten-year OIS rate, and obtained using country-level data. Shaded areas are 68% and 90% posterior coverage bands. Sample 2008:01-2019:12.

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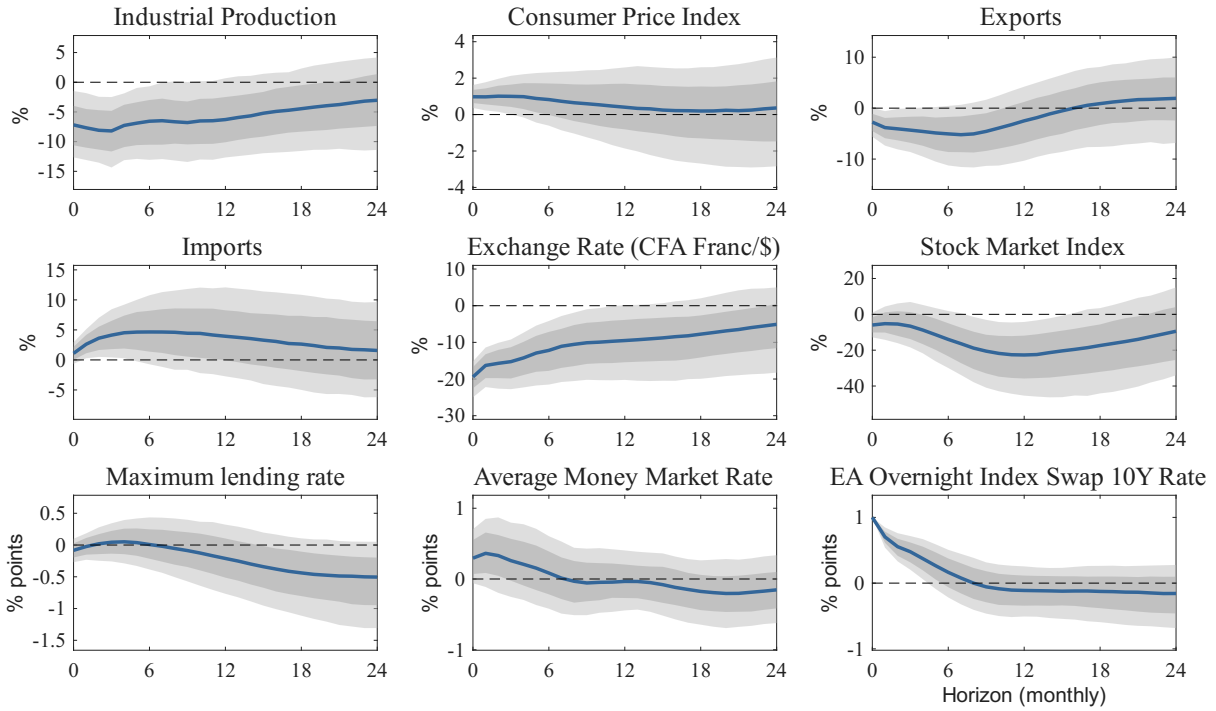

Note: The figure reports the WAEMU impulse responses to an unconventional monetary policy shock in the euro area, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2002:01-2019:12.

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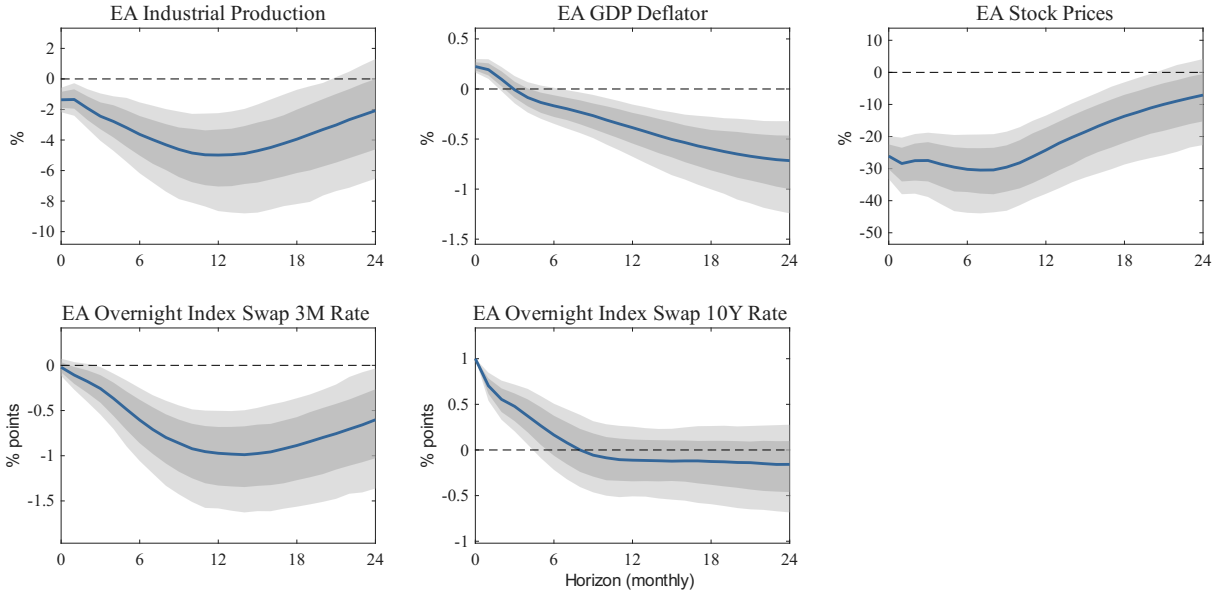

Note: The figure reports the euro area impulse responses to an unconventional monetary policy shock, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2002:01-2019:12.

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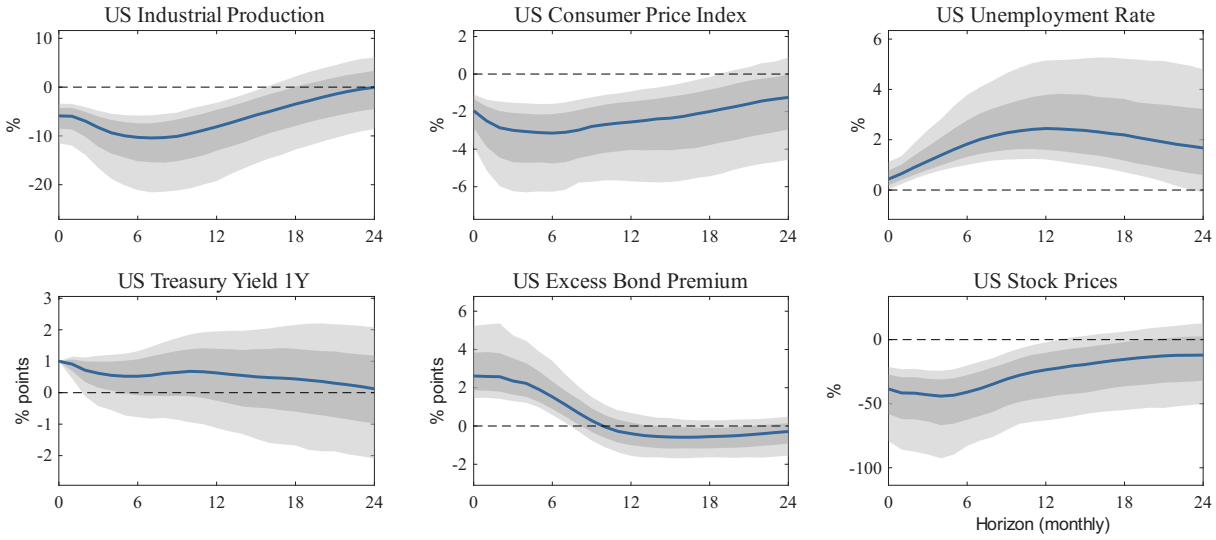

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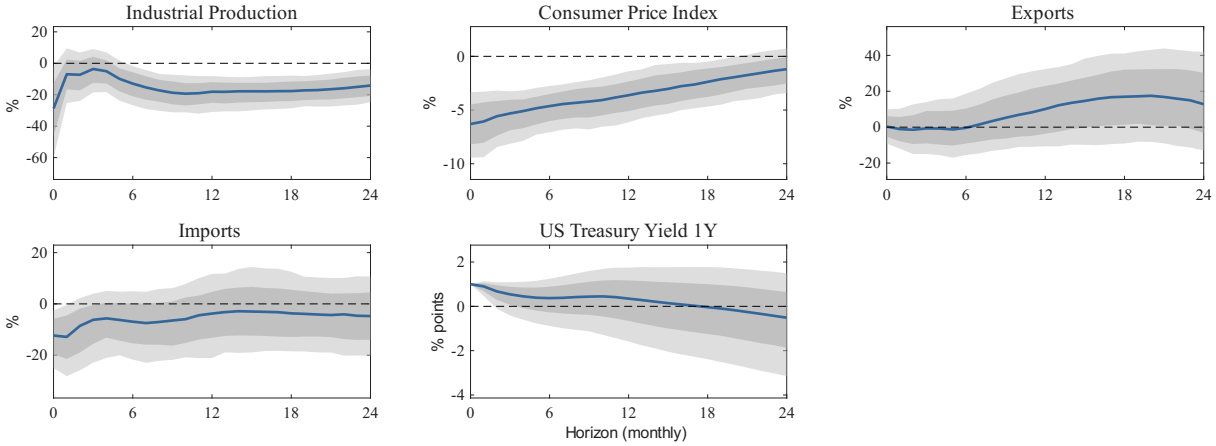

Note: The figure reports the WAEMU impulse responses to a conventional monetary policy shock, normalised to induce a 100 basis point increase in the one-year US treasury yield, and obtained using country-level data. Shaded areas are 68% and 90% posterior coverage bands. Sample 2000:01-2018:12.

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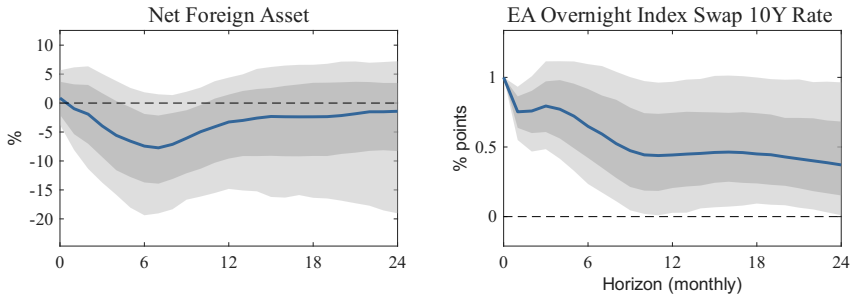

Note: The figure reports the WAEMU net foreign asset impulse responses to an unconventional monetary policy shock in the euro area, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2008:m1-2019:m12.

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Note: The figure reports the impulse responses to an unconventional monetary policy shock in the US, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2008:01-2018:12.

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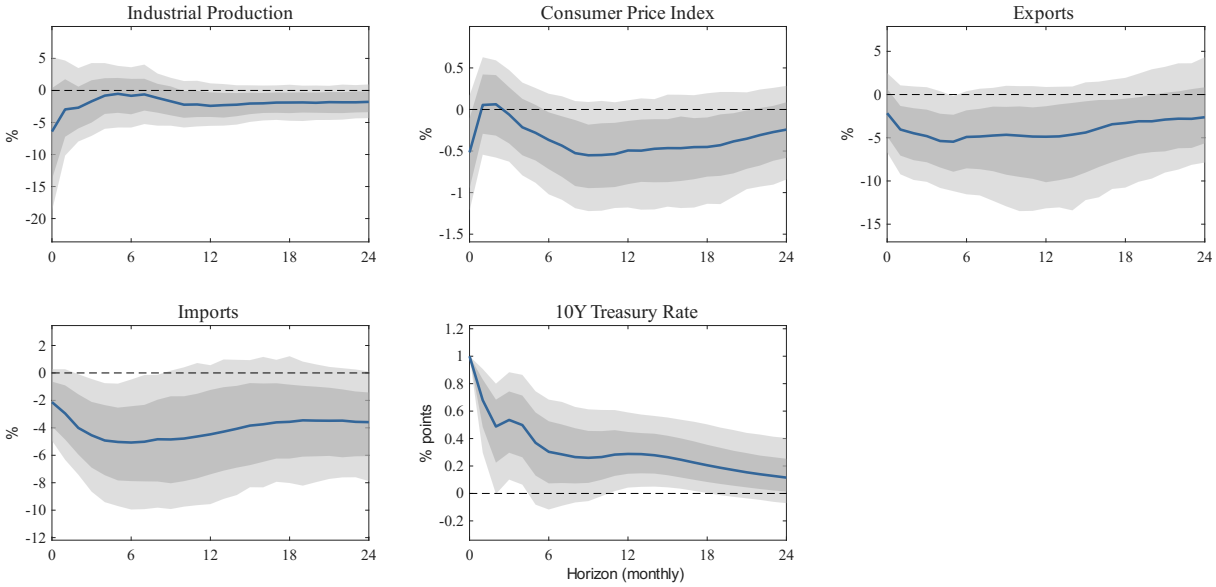

Note: The figure reports the WAEMU impulse responses to an unconventional monetary policy shock in the US, normalised to induce a 100 basis point increase in the ten-year OIS rate, and obtained using country-level data. Shaded areas are 68% and 90% posterior coverage bands. Sample 2008:01-2018:12.

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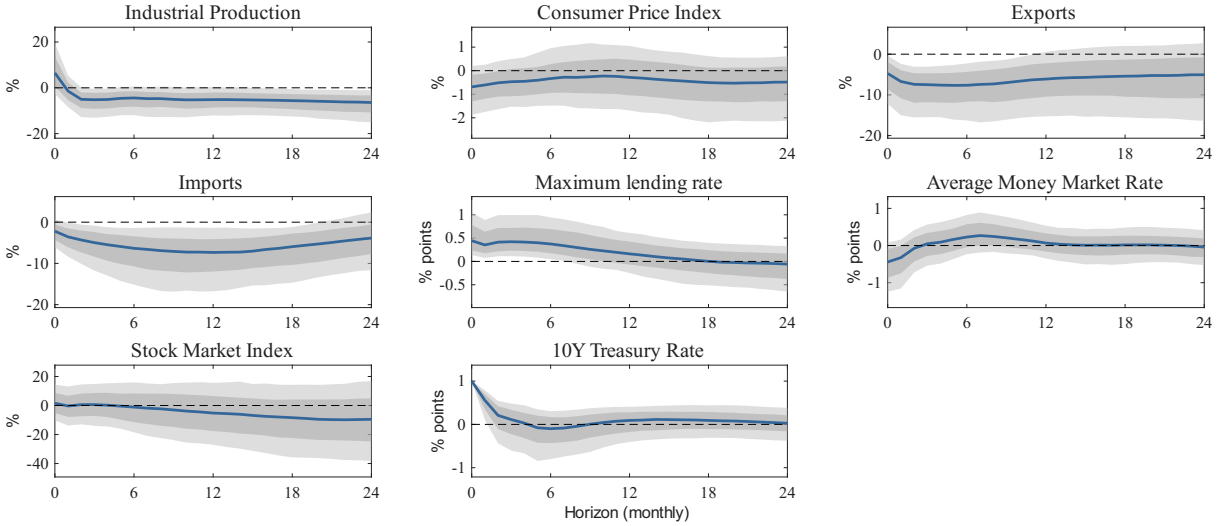

Note: The figure reports the WAEMU impulse responses to an unconventional monetary policy shock in the US, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2000:01-2018:12.

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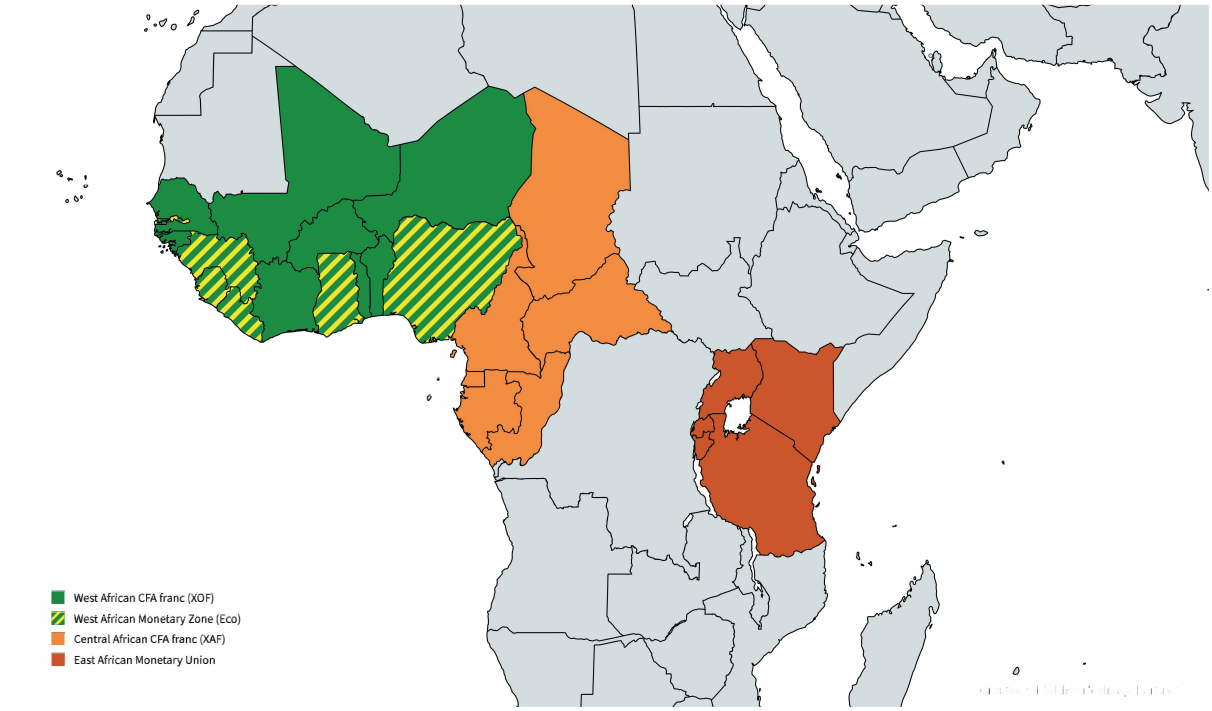
Note: The figure reports the US impulse responses to an unconventional monetary policy shock, normalised to induce a 100 basis point increase in the ten-year OIS rate. Shaded areas are 68% and 90% posterior coverage bands. Sample 2000:01-2018:12.

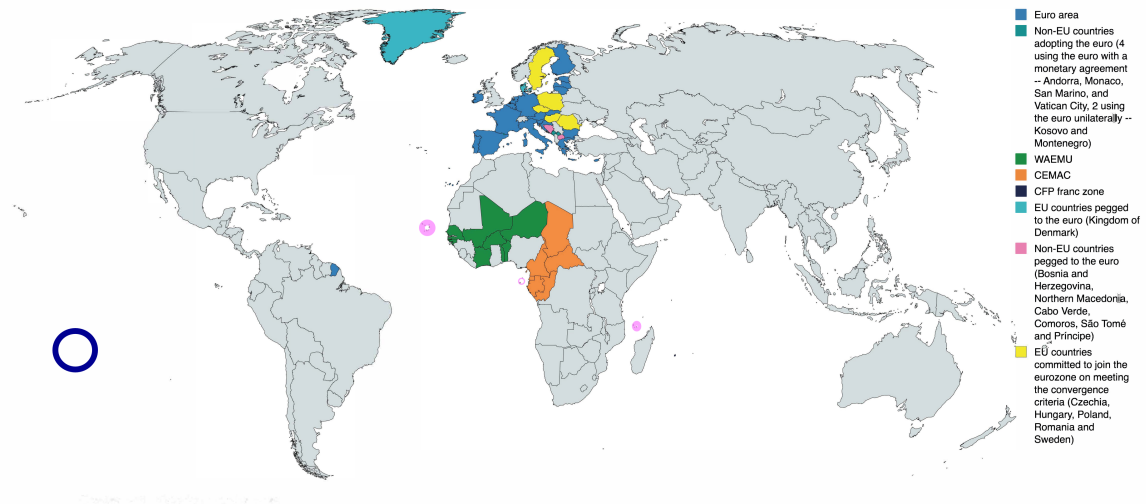
B Existing and proposed African monetary unions

Figure XV: Existing and proposed African monetary unions



Notes: The figure reports the existing and proposed monetary unions in Africa.

Figure XVI: The euro and the euro pegs



Notes: The figure shows the euro area along with the countries and the monetary areas that either are pegged to the euro, or have adopted the euro.

C Additional model derivations

C.1 Thresholds

Figure 18 shows how the responses of the domestic economy to external and internal monetary policy tightenings vary with the parameters governing the strength of the financial and commodity channels, denoted by f and h, respectively. More specifically, the left-hand panel reports the case of the euro area, while the right-hand panel refers to the US In both cases, for simplicity, the parameters associated with the third economy are set to zero. For instance, in the euro area panel all parameters with subscript 2 are set equal to zero, and vice versa for the US panel.

We begin with the left-hand panel, which focuses on the euro area case. The threshold values that appear in the figure are:[1]

$$\bar{f}_1 = b_1 + \frac{1 + a_1}{e}, \tag{2}$$

$$\hat{f}_1 = b_1 + \frac{a_1}{e_1}, \tag{3}$$

$$\bar{h} = \frac{-e(\frac{\partial Y}{\partial I^{EA}})}{c_1 l}. \tag{4}$$

Turning to the right-hand panel, the threshold values reported in the figure are:[2]

$$\bar{f}_2 = b_2 + \frac{1 + a_2}{2}, \tag{6}$$

$$\hat{f}_2 = b_2 - \frac{c_2 a_2}{A}, \tag{7}$$

$$\bar{h} = \frac{e(\frac{\partial Y}{\partial I^{US}}) - K}{c_2 l}, \tag{8}$$

where $A = (d_2 + g_2)[1 + m(\theta - 1)] - c_2 e_2$ and $K = (d_2 + g_2)m(1 - \theta)$.

[1] For simplicity, these thresholds are derived under the assumption that

$$b_1 + \frac{1 + a_1}{e} < b_1 + \frac{a_1}{e_1}. \tag{1}$$

[2] For simplicity, these thresholds are derived under the assumption that

$$b_2 + \frac{1 + a_2}{2} < b_2 - \frac{c_2 a_2}{A}. \tag{5}$$

C.2 Reserves

In the main text, we analyzed how reserves respond to external monetary contractions by augmenting the model with the following equation:

$$R = \underbrace{a_1(Y^{EA} - Y) + b_1(\bar{E}^{EA} + \Pi^{EA} - \Pi)}_{\text{EA net export}} + \underbrace{k_1(I - I^{EA})}_{\text{EA capital flows}}. \tag{9}$$

In this section, we extend this specification by also incorporating the balance-of-payments components related to the US. In this case, the equation for reserves becomes:

$$R = \underbrace{a_1(Y^{EA} - Y) + b_1(\bar{E}^{EA} + \Pi^{EA} - \Pi)}_{\text{EA net export}} + \underbrace{k_1(I - I^{EA})}_{\text{EA capital flows}} + \tag{10}$$

$$+ \underbrace{a_2(Y^{US} - Y) + b_2(E^{US} + \Pi^{US} - \Pi)}_{\text{US net export}} + \underbrace{k_2(I - I^{US})}_{\text{US capital flows}}. \tag{11}$$

Solving the model with the extended equation and computing the response of reserves to a monetary contraction in the euro area yields the following expression:

$$\frac{\partial R}{\partial I^{EA}} = -a_1 c_1 - b_1[c_1 e_1 + d_2 m(\theta - 1)] - b_2 d_2[m(\theta - 1) + 1] - k_1. \tag{12}$$

Although the expression now includes an additional term related to US net exports, the qualitative interpretation of the result remains unchanged.

D Derivation of thresholds

D.1 Threshold analysis (Sections 7.2–7.3)

This subsection derives all the threshold values underlying the figure describing the parameter-space (h, f_{EA}) for the euro area and US spillovers.

D.1.1 EA spillovers

Abstracting from indirect effects via the US, the output and inflation responses to a euro area monetary tightening are:[3]

$$\frac{\partial Y}{\partial I^{EA}} = \frac{c_{EA}[-a_{EA} - e_{EA}(b_{EA} - f_{EA})]}{\psi}, \tag{13}$$

$$\frac{\partial \Pi}{\partial I^{EA}} = e\frac{\partial Y}{\partial I^{EA}} - c_{EA}hl. \tag{14}$$

The sign of the response of domestic output to euro area tightening depends on the sign of the numerator and the denominator. The denominator ψ equals zero when

$$1 + a_{EA} + e(b_{EA} - f_{EA}) = 0, \tag{15}$$

which gives

$$\hat{f}_{EA} = \frac{1 + a_{EA}}{e} + b_{EA}. \tag{16}$$

We note two things. First, $\hat{f}_{EA}$ is positive. Second, for $f_{EA} > \hat{f}_{EA}$, $\psi < 0$ and vice versa. This also implies that if financial spillovers are greater than $\hat{f}_{EA}$, domestic monetary policy transmission is perverse i.e., $\partial Y/\partial I = -c/\psi > 0$.

The numerator of (13) equals zero when

$$-a_{EA} - e_{EA}b_{EA} + e_{EA}f_{EA} = 0 \qquad \Longrightarrow \qquad \bar{\bar{f}}_{EA} = \frac{a_{EA}}{e_{EA}} + b_{EA}. \tag{17}$$

[3]The full formula including indirect US effects adds the term $-d_{US}[(b_{US} - f_{US}) + m(\theta - 1)(b_{EA} + b_{US} - f_{EA} - f_{US})]$ to the numerator. For the WAEMU, this simplification is well justified. First, $\theta \approx 1$ (near-complete peg to the euro) makes $m(\theta - 1) \approx 0$, killing the import price feedback channel. Second, low f_{US} (shallow financial markets) makes the indirect financial channel $d_{US}f_{US}$ negligible. The dominant omitted term is $-d_{US}b_{US}$ (the US trade channel), which is contractionary. The simplification therefore slightly understates the total contraction but does not change the qualitative structure of the figure: the three regions and the threshold curves survive, with only a quantitative shift in the threshold values.

For $f_{EA} < \bar{\bar{f}}_{EA}$ the numerator is negative and vice versa. Note that $\hat{f}_{EA} > \bar{\bar{f}}_{EA}$ when

$$\hat{f}_{EA} - \bar{\bar{f}}_{EA} = \frac{1 + a_{EA}}{e} - \frac{a_{EA}}{e_{EA}}. \tag{18}$$

This is positive as long as $\frac{1+a_{EA}}{e}$ is greater than $\frac{a_{EA}}{e_{EA}}$. When this condition holds, the parameter space is split into three regions of financial spillovers – weak ($0 < f < \bar{\bar{f}}_{EA}$), intermediate ($\bar{\bar{f}}_{EA} < f < \hat{f}_{EA}$), and strong ($\hat{f}_{EA} < f$).

We can now determine the sign of $\partial Y/\partial I^{EA}$ in these three regions. When financial spillovers are weak, euro area monetary policy leads to a decline in domestic output. For intermediate financial spillovers, the positive effect from real appreciation of the WAEMU currency via the financial channel overpowers the negative effect from foreign demand and results in a positive response of domestic output. The real appreciation results from a decline in euro area inflation. Finally, when financial spillovers are strong, the response of domestic output to euro area monetary policy is negative since the IS multiplier itself turns negative. Interestingly, in this region, domestic monetary policy transmission also becomes perverse i.e., $\partial Y/\partial I = -c/\psi > 0$.

Next, we examine the effect of monetary policy on inflation and the role of commodity prices. For weak and strong financial spillovers, $\partial Y/\partial I^{EA} < 0$ and the response of inflation is always positive. For intermediate financial spillovers, we can find a threshold level of h by setting $\partial \Pi/\partial I^{EA} = 0$ in (14):

$$e\frac{\partial Y}{\partial I^{EA}} = c_{EA} h l \qquad \Longrightarrow \qquad \bar{h}(f_{EA}) = \frac{e}{l} \cdot \frac{-a_{EA} - e_{EA}(b_{EA} - f_{EA})}{\psi}. \tag{19}$$

Further note that in the intermediate financial spillovers region:

- at $f_{EA} = \bar{\bar{f}}_{EA}$: the numerator is zero, so $\bar{h} = 0$;
- as $f_{EA} \to \hat{f}_{EA}^{-}$: $\psi \to 0^{+}$, so $\bar{h} \to +\infty$.

Hence, for $h > \bar{h}(f_{EA})$, the deflationary effect from commodity price channel dominates and $\partial \Pi/\partial I^{EA} < 0$. For $h < \bar{h}(f_{EA})$, the output boom drives $\partial \Pi/\partial I^{EA} > 0$ and results in higher inflation.

To summarize, the parameter space (h, f_{EA}) is divided into three horizontal bands:

1. $f_{EA} < \bar{\bar{f}}_{EA}$: $\partial Y/\partial I^{EA} < 0$, $\partial Y/\partial I < 0$, $\partial \Pi/\partial I^{EA} < 0$ for all h.

2. $\bar{\bar{f}}_{EA} < f_{EA} < \hat{f}_{EA}$: $\partial Y/\partial I^{EA} > 0$, $\partial Y/\partial I < 0$, and $\partial \Pi/\partial I^{EA}$ changes sign at $\bar{h}(f_{EA})$.

3. $f_{EA} > \hat{f}_{EA}$: $\partial Y/\partial I^{EA} < 0$, $\partial Y/\partial I > 0$ (perverse), $\partial \Pi/\partial I^{EA} < 0$ for all h.

D.1.2 US spillovers

Abstracting from the indirect real exchange rate feedback through domestic inflation, the output and inflation responses to a US monetary tightening are:[4]

$$\frac{\partial Y}{\partial I^{US}} = \frac{1}{\psi}\Big\{c_{US}[-a_{US} - e_{US}(b_{US} - f_{US})] + (d_{US} + g_{US})(b_{US} - f_{US})\Big\}, \tag{20}$$

$$\frac{\partial \Pi}{\partial I^{US}} = e\frac{\partial Y}{\partial I^{US}} - c_{US}hl - (d_{US} + g_{US})m(\theta - 1). \tag{21}$$

This gives us a threshold for $\bar{\bar{f}}_{US}$ by setting the numerator of (20) to zero

$$c_{US}[-a_{US} - e_{US}b_{US} + e_{US}f_{US}] + (d_{US} + g_{US})(b_{US} - f_{US}) = 0. \tag{22}$$

which gives

$$\bar{\bar{f}}_{US} = \frac{c_{US}(a_{US} + e_{US}b_{US}) - (d_{US} + g_{US})b_{US}}{c_{US}e_{US} - (d_{US} + g_{US})}. \tag{23}$$

This threshold exists (i.e. is finite and positive) only when $c_{US}e_{US} \neq d_{US} + g_{US}$. Another threshold comes from the denominator $\hat{f}_{US}$, as in the case for the euro area (since ψ is symmetric):

$$\hat{f}_{US} = \frac{1 + a_{US}}{e} + b_{US}. \tag{24}$$

Note that $\hat{f}_{US} > \bar{\bar{f}}_{US}$ when

$$\hat{f}_{US} - \bar{\bar{f}}_{US} = \frac{1 + a_{US}}{e} - \frac{a_{US}c_{US}}{c_{US}e_{US} - (d_{US} + g_{US})}. \tag{25}$$

Assuming that $\hat{f}_{US} > \bar{\bar{f}}_{US}$, the parameter space is split into three regions of financial spillovers – weak ($0 < f < \bar{\bar{f}}_{US}$), intermediate ($\bar{\bar{f}}_{US} < f < \hat{f}_{US}$), and strong ($\hat{f}_{US} < f$). The response of output is dependent on the region of financial spillovers. With

[4]The full formula adds $m(\theta - 1)(b_{EA} + b_{US} - f_{EA} - f_{US})$ inside the $(d_{US} + g_{US})$ bracket. Since $\theta < 1$ and $b_{EA} + b_{US} - f_{EA} - f_{US} > 0$ (from $\psi > 0$), this term is negative: it captures how the dollar appreciation raises domestic inflation through the Phillips curve (mE term in $\Pi = eY + mE + hC$), which then appreciates the real exchange rate and partially offsets the expenditure-switching effect. For the WAEMU with $\theta \approx 1$, $m(\theta - 1) \approx 0$ and this feedback is negligible. The simplification slightly overstates the expenditure-switching channel, but the error is proportional to $(1 - \theta)$ and does not alter the qualitative structure of the figure.

weak financial spillovers, the response is negative if the negative effect of foreign demand outweighs the positive effect through net exports. As financial spillovers become stronger and cross $\bar{\bar{f}}_{US}$, when $c_{US}e_{US} > d_{US} + g_{US}$, the effect of lower US prices outweighs the appreciation of the dollar, and results in a positive output response to US monetary policy tightening.

Next, we examine the effect of US monetary policy on inflation and the role of commodity prices. We obtain an inflation threshold curve $\bar{h}(f_{US})$ by setting $\partial\Pi/\partial I^{US} = 0$ in (21):

$$e\frac{\partial Y}{\partial I^{US}} + (d_{US} + g_{US})m(1-\theta) = c_{US}hl, \tag{26}$$

which gives

$$\bar{h}(f_{US}) = \frac{1}{c_{US}l}\left[e\frac{\partial Y}{\partial I^{US}} + (d_{US} + g_{US})m(1-\theta)\right]. \tag{27}$$

The key difference from the euro area case is the exchange rate term $(d_{US}+g_{US})m(1-\theta) > 0$. This positive constant shifts the threshold curve upward, meaning that even when $\partial Y/\partial I^{US} < 0$, which is the case for $f_{US} < \bar{\bar{f}}_{US}$, the threshold $\bar{h}$ can still be positive. This can happen because there is inflationary pressure from the dollar appreciation that exceeds the deflationary output effect. If $\bar{h}$ is indeed positive, then for any $h > \bar{h}$, $\partial\Pi/\partial I^{US} < 0$ as the commodity price channel is strong enough to offset the effect through output and exchange rate movements. This is the crucial asymmetry with the euro area threshold. For the euro area, the inflation threshold curve only exists in the intermediate (output-positive) region. For the US, it also spans the baseline region of weak financial spillovers.

To summarise, the parameter space (h, f_{US}) has the same three-region output structure as the euro area case (weak, intermediate, strong financial spillovers). However, the inflation threshold curve $\bar{h}(f_{US})$ extends across all output regions where the exchange rate inflationary effect is not dominated by the output contraction, including the baseline contractionary region. The WAEMU, with low f and high h, sits in the bottom-right corner of both panels, ensuring $\partial Y/\partial I^{US} < 0$ and $\partial\Pi/\partial I^{US} < 0$.