

# Macroeconomics B, EI060

## Class 7

### Currency crises, foreign exchange interventions

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# What you will get from today class

- Current account crises.
  - First generation: unsustainable policy (Harms X.3.2, Obstfeld and Rogoff (secondary) 8.4).
  - Second generation: multiple equilibria (Harms X.3.3).
  - Third generation: linkage with banks (Harms X.3.4, Vegh (brief, secondary) 17.7).
- Foreign exchange interventions.
  - Impact when interest parity does not hold (Harms VIII.6).
  - Empirical evidence (Fratzscher, Gloede, Menkhoff, Sarno, and Stöhr 2019).

# A question to start

*Currency crises (failure of an exchange rate peg) often occur as a surprise. This points to multiple equilibria, with a limited role for fundamentals.*

Do you agree? Why or why not?

# FIRST GENERATION CRISES

# Money and exchange rate

- Monetary policy cannot both follow a domestic objective and maintain an exchange rate peg.
  - Insight: the break ends in a sudden and perfectly predictable manner.
- Building blocks are UIP, money demand, and PPP:

$$\begin{aligned}i_{t+1}^H &= i_{t+1}^F + \mathbb{E}_t(e_{t+1}) - e_t \\ m_t - p_t &= \phi y_t - \lambda i_{t+1}^H \\ p_t &= e_t + p_t^F\end{aligned}$$

- Exchange rate solution (assume  $p_t^F + \phi y_t - \lambda i_{t+1}^F = 0$  for simplicity):

$$m_t - e_t = -\lambda (\mathbb{E}_t(e_{t+1}) - e_t)$$

- A peg requires  $\mathbb{E}_t(e_{t+1}) - e_t = 0$  and constant money supply:

$$e_t = e_{t+1} = \bar{m}$$

# Central bank balance sheet

- Liabilities: money,  $M_t$ . Assets: domestic currency bonds,  $D_t$ , and foreign currency bonds (reserves),  $R_t$ :

$$M_t = D_t + R_t \quad ; \quad m_t = \ln(D_t + R_t)$$

- Domestic policy: the central bank steadily acquires domestic currency bonds at a rate  $\mu$  (usual reason: finance the government deficit):

$$\ln(D_{t+1}) = \ln(D_t) + \mu$$

- Keeping the money constant requires that domestic bond purchases are offset by sales of foreign currency bonds.
  - At some points reserves will run out.
  - Everything is fully expected.

# Exchange rate dynamics

- The peg breaks at time  $T$  (endogenous). Money is constant until then at  $\bar{m}$ , and after that money grows at the rate  $\mu$ .

$$e_{T-1} = \bar{m} \quad ; \quad e_T = \ln(D_T) + \lambda\mu$$

- Can it be that reserves smoothly run out:

$$\bar{m} = m_{T-1} = m_T = \ln(D_T)?$$

- No. This would imply a discrete and fully expected depreciation jump:  
 $e_T - e_{T-1} = \lambda\mu > 0$ .
  - Incompatible with interest parity (monetary model implies that the exchange rate can jump, but only unexpectedly).
- Parity requires  $e_T = e_{T-1}$ , hence:

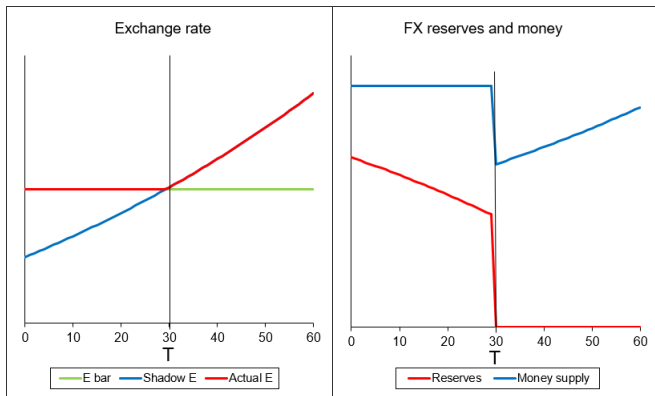
$$\bar{m} = \ln(D_T) + \lambda\mu$$

$$m_{T-1} = m_T + \lambda\mu > m_T$$

- The money supply drops down. This requires reserve to jump down from  $R_{T-1}$  to zero. A run on reserves that is fully predicted.

# Paths of exchange rate and reserves

- Shadow exchange rate: value that would prevail under a float with only domestic bonds (at the value of the period). Trend depreciation as domestic bonds increase.
- Exchange rate breaks when the the shadow rate reaches the pegged value.





# Timing of the break

- Floating exchange rate = pegged value at the time of break:

$$\bar{m} = \ln(D_T) + \lambda\mu$$

- Initial money equal to its value at the starting period 0:

$$\bar{m} = \ln(D_0 + R_0)$$

- As  $\ln(D_T) = \ln(D_0) + T\mu$ , we get the period of break:

$$T = \frac{1}{\mu} \ln\left(1 + \frac{R_0}{D_0}\right) - \lambda$$

- Longer lasting peg ( $T$  higher) with limited purchases of domestic bonds  $\mu$ , impact impact of interest on money demand (low  $\lambda$ ), and higher initial reserves (high  $R_0/D_0$ ).
- The run on reserves just reflects an unsustainable policy mix.
  - But many countries experienced crises with a policy mix that was not clearly unsustainable, and crises were unexpected.
  - Note that the only role of reserves is to be an asset that can be sold. There is nothing particular about it being in foreign currency.

# SECOND GENERATION CRISES

# Domestic - foreign tension

- Central bank minimizes a loss function:

$$L = \frac{1}{2} \left\{ \phi (x_t - \bar{x})^2 + (\Delta e_t)^2 \right\} + c_{\Delta e_t > 0}$$

- Volatility of the output gap  $x_t$  around a reference level  $\bar{x}$ .
  - Volatility of the exchange rate  $\Delta e_t$ , which is zero if the peg is maintained.
  - Discrete cost  $c$  if the peg is abandoned (we focus on depreciation).
- The output gap reflects an aggregate supply, with higher output when the exchange rate depreciates more than expected (unexpected inflation as we have PPP):

$$x_t = \theta \left( \Delta e_t - \Delta e_t^{\text{expected}} \right)$$

- Tension between keeping the peg and accepting a depreciation to raise output.

# Loss under discretion

- If the central bank decides to abandon the peg, it sets  $\Delta e_t$  to minimize the loss given  $\Delta e_t^{\text{expected}}$ :

$$\Delta e_t = \frac{\phi\theta}{1 + \phi\theta^2} \left( \theta\Delta e_t^{\text{expected}} + \bar{x} \right)$$

- Higher depreciation if the reference gap is high, and if the market expects a high depreciation.
- If the exchange rate matches expectations (conditional on abandoning the peg):  $\Delta e_t = \Delta e_t^{\text{expected}} = \phi\theta\bar{x}$ .
- The loss function reflects the discrete cost of abandoning the peg:

$$L^{\text{float}} = \frac{\phi}{2(1 + \phi\theta^2)} \left( \bar{x} + \theta\Delta e_t^{\text{expected}} \right)^2 + c$$

- If the peg is maintained, , the loss is  $\Delta e_t = 0$ :

$$L^{\text{peg}} = \frac{\phi}{2} \left( \bar{x} + \theta\Delta e_t^{\text{expected}} \right)^2$$

# To peg or not?

- Abandon the peg if the loss is reduced under a float  $L^{\text{peg}} > L^{\text{float}}$ :

$$\frac{\phi}{2} \left( \bar{x} + \theta \Delta e_t^{\text{expected}} \right)^2 > \frac{1}{1 + \phi \theta^2} \frac{\phi}{2} \left( \bar{x} + \theta \Delta e_t^{\text{expected}} \right)^2 + c$$

- Trade-off reduced loss from  $\left( \bar{x} + \theta \Delta e_t^{\text{expected}} \right)^2$  vs. fixed cost (always float in the absence of a fixed cost).
- The peg is abandoned if the cost is below a critical value:

$$c < c^{\text{critical}} = \frac{(\phi \theta)^2}{2(1 + \phi \theta^2)} \left( \bar{x} + \theta \Delta e_t^{\text{expected}} \right)^2$$

- The critical value is higher (peg less sustainable) if the reference gap  $\bar{x}$  is high, if the market expects a high depreciation, if the central bank care about output ( $\phi$  high) and if the exchange rate impacts output ( $\theta$  high).

# Threshold exchange rate

- The critical cost  $c = c^{\text{critical}}$  translates into a critical value of the exchange rate:

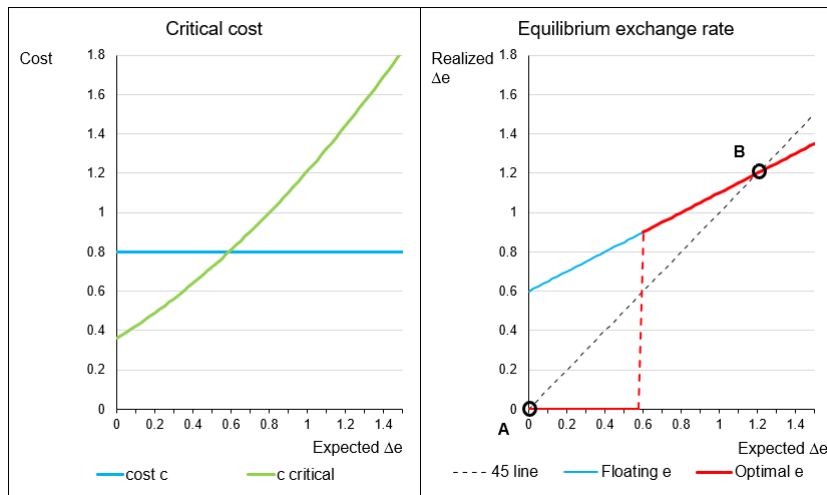
$$\Delta \bar{e}_t^{\text{expected}} = \frac{\sqrt{2(1 + \phi\theta^2)c}}{\phi(\theta)^2} - \frac{\bar{x}}{\theta}$$

- If  $\Delta e_t^{\text{expected}} < \Delta \bar{e}_t^{\text{expected}}$ , the peg is abandoned.
  - More likely if the reference gap  $\bar{x}$  is high, or if the fixed cost  $c$  is low.

- Consider that  $\Delta \bar{e}_t^{\text{expected}} < 0$ 
  - Even when markets do not expect a depreciation ( $\Delta e_t^{\text{expected}} = 0$ ) the central bank abandons the peg:  $\Delta e_t^{\text{expected}} > \Delta \bar{e}_t^{\text{expected}}$ .
  - $\Delta e_t^{\text{expected}} = 0$  is not an equilibrium. The only equilibrium is a depreciation  $\Delta e_t = \Delta e_t^{\text{expected}} = \phi \theta \bar{x}$ , and the peg is abandoned.
- Consider that  $\Delta \bar{e}_t^{\text{expected}} > \phi \theta \bar{x}$ .
  - A depreciation is not an equilibrium: if it is chosen and expected, the exchange rate,  $\phi \theta \bar{x}$ , remains below  $\Delta \bar{e}_t^{\text{expected}}$ . The peg is kept.
- Consider that  $0 < \Delta \bar{e}_t^{\text{expected}} < \phi \theta \bar{x}$ , there are two equilibria:
  - One where the peg is kept.
  - One where the peg is abandoned and  $\Delta e_t = \Delta e_t^{\text{expected}} = \phi \theta \bar{x}$ .

# Multiple equilibria

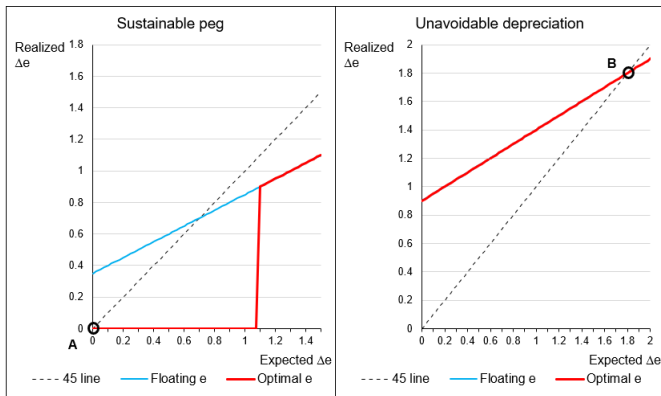
- Parameters:  $\phi = \theta = 1$ ,  $c = 0.8$ ,  $\bar{x} = 1.2$ . This implies  $\Delta \bar{e}_t^{\text{expected}} = 0.59$ , and there are two equilibria.





# Unique equilibrium

- Left panel:  $\bar{x} = 0.7$ , which implies  $\Delta \bar{e}_t^{\text{expected}} = 1.09 > \phi \theta \bar{x}$  and the peg is the only equilibrium.
- Right panel:  $\bar{x} = 1.87$ , which implies  $\Delta \bar{e}_t^{\text{expected}} = -0.01 < 0$  and the peg cannot be kept.



# Insights from the model

- Countries may not be so committed to keeping a peg.
- If markets expect them to abandon the peg, they may chose to do so.
  - But they would have kept the peg of markets had expected them to do so.
  - Multiple equilibria.
- Fundamentals matter.
  - Very bad fundamentals (high  $\bar{x}$ , could reflect an adverse shock) imply the peg will be abandoned for sure.
  - Good fundamentals (low  $\bar{x}$ ) imply the peg will survive for sure.
  - Intermediate fundamentals put the country is a risky zone of multiple equilibria.
- Example: crisis of the European Monetary System in 1992 following the German reunification.

# THIRD GENERATION CRISES

# Leveraged financial intermediaries

- Asian crisis of 1997-1998: fiscal fundamentals were good, but financial intermediaries had foreign exchange exposure.
  - Bank run in a multiple currencies context.
- Illustration with a two-period model where banks are active in domestic and foreign currency.
  - Bank  $i$  has domestic currency earnings in the second period:  $Y_2^{H,i}$ .
  - In both periods, it has foreign currency earnings,  $Y_1^{F,i}$  and  $Y_2^{F,i}$ , and payments,  $D_1^{F,i}$  and  $D_2^{F,i}$ .
  - Maturity mismatch, as first period foreign currency net earnings are negative:  $Y_1^{F,i} - D_1^{F,i} < 0$ .
  - Currency mismatch. It needs the domestic currency earnings to cover the fact that the present value of its foreign currency activity is negative ( $i_1^H$  is the domestic interest rate and  $E_2^{\text{expected}}$  the expected exchange rate):

$$0 > E_1 \left( Y_1^{F,i} - D_1^{F,i} \right) + \frac{1}{1 + i_1^H} E_2^{\text{expected}} \left( Y_2^{F,i} - D_2^{F,i} \right)$$

# Bank net worth

- Domestic currency net worth is the present value of net earnings (using the expected future exchange rate):

$$V_1^{H,i} = E_1 \left( Y_1^{F,i} - D_1^{F,i} \right) + \frac{1}{1 + i_1^H} \left[ Y_2^{H,i} + E_2^{\text{expected}} \left( Y_2^{F,i} - D_2^{F,i} \right) \right]$$

- Using the interest rate parity,  $1 + i_1^H = (1 + i_1^F) \left( E_2^{\text{expected}} / E_1 \right)$ , the net worth in foreign currency reflects the foreign exchange rate:

$$\tilde{V}_1^{H,i} = \frac{Y_2^{H,i}}{(1 + i_1^F) E_2^{\text{expected}}} + \left( Y_1^{F,i} - D_1^{F,i} \right) + \frac{1}{1 + i_1^F} \left( Y_2^{F,i} - D_2^{F,i} \right)$$

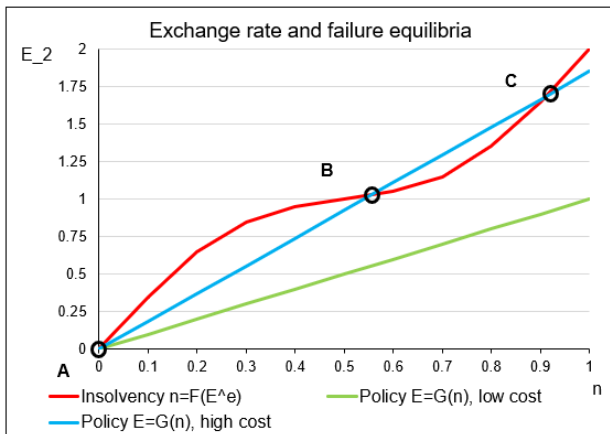
- We start at a situation where  $E_1 = E_2^{\text{expected}} = 1$  and  $\tilde{V}_1^{H,i} > 0$ .
- If expectations shifts towards a domestic depreciation,  $E_2^{\text{expected}} > 1$ , this lowers the foreign currency value  $\tilde{V}_1^{H,i}$ .
  - Insolvency, from the point of view of foreign lenders, when  $\tilde{V}_1^{H,i} < 0$ .

# Equilibrium

- There are many banks in the country, with different values of  $E_2^{\text{expected}} > 1$  that put them in bankruptcy.
  - Cumulative distribution  $F$  of the threshold expected exchange rate.
- Positive relation between the expected exchange rate and the share  $n$  of banks that are insolvent:  $n = F(E_2^{\text{expected}})$ .
- The government can bail out the banks.
  - Use reserves, and if not enough needs to resort to lender of last resort operations in domestic currency, leading the peg to fail.
  - Positive relation between the realized exchange rate  $E_2$  and the share  $n$  of banks which need a rescue:  $E_2 = G(n)$ .
- Equilibrium at the intersection of the lines,  $E_2^{\text{expected}} = E_2$ . As both relations have a positive slope, multiple equilibria are possible.
  - The peg survives if  $E_2 = G(n)$  keeps  $E_2$  low, for instance thank to abundant reserves.
  - It also survives if  $n = F(E_2^{\text{expected}})$  shows high values of  $E_2^{\text{expected}}$ , for instance thanks to macroprudential policies.

# Multiple equilibria

- The two lines can cross in several instances. If  $n = F(E_2^{\text{expected}})$  is above  $E_2 = G(n)$ , the peg survives.



# A fuller model (Vegh)

- Twin crises, with a banking crisis leading to a currency crisis.
  - The cost of bailing out the bank behaves as the unsustainable fundamental in the first generation model.
  - Cost can be big even if the government's finances are initially fine.
- Small open economy, initially under a peg.
- Bad shock at time 0 weakens the bank (permanent drop of constant endowment).
  - Earnings on endowment insufficient to pay the return on deposits, banks borrow (unsustainably) from foreign investors.
- Banking crisis at time  $T_1$ : foreign investors unwilling to lend more.
  - The government takes over the bank.
  - Support from abroad (IMF) makes the bank solvent on a forward looking flow basis.
- Debt to foreign investors remains.
  - If the government reserves can cover this, the peg is sustainable.
  - Otherwise, currency crisis at time  $T_2$  with abandonment of the peg.



# FOREIGN EXCHANGE INTERVENTIONS

# Balance of payments

- Exchange rate models indicate that changing money supply affect the exchange rate.
  - Do reserves matter in addition (i.e. for an unchanged monetary policy)?
- Current account equal to (non-reserve) financial account and reserves accumulation ( $\Delta R_{t+1}$ ):

$$CA_t = FA_t^{NR} + \Delta R_{t+1}$$

- Monetary policy: interest rate rule: follows the foreign rate, reacts to the exchange rate, and shifts  $\xi_t$ :

$$i_t^H = i_t^F + \delta e_t + \xi_t$$

- Policy maker also change reserves  $\Delta R_{t+1}$ .

- Current account higher when the currency is weak:

$$CA_t = \gamma e_t$$

- Non-reserve financial account reflects deviations from uncovered interest parity:

$$FA_t^{NR} = \alpha \left( i_t^F - i_t^H + \mathbb{E}_t e_{t+1} - e_t \right)$$

- Higher foreign interest rate / lower domestic interest rate / expectation of domestic depreciation raise capital outflows and limit capital inflows.
- $\alpha \rightarrow \infty$  is the case of UIP always holdings.

# Equilibrium exchange rate

- Substitute the various elements in the balance of payments:

$$CA_t = FA_t^{NR} + \Delta R_{t+1}$$

$$\gamma e_t = \alpha (-\delta e_t - \xi_t + \mathbb{E}_t e_{t+1} - e_t)$$

- Exchange rate solution (we consider that  $\Delta R_{t+1}$  and  $\xi_t$  are on-off changes, so  $\mathbb{E}_t e_{t+1} = 0$ ):

$$e_t = \frac{-\alpha \xi_t + \frac{\Delta R_{t+1}}{\alpha}}{1 + \delta + \frac{\gamma}{\alpha}}$$

- An interest increase ( $\xi_t > 0$ ) appreciates the currency (tighter policy, similar to a reduction of money supply).
- An increase in reserves ( $\Delta R_{t+1} > 0$ ) depreciates the currency.
  - It requires a positive current account, or a negative financial account, both achieved by a weaker currency (expectation of appreciation draws in foreign capital).
  - The effect is present only with a finite  $\alpha$ , i.e. there can be deviations from UIP.

# Introducing shocks

- Enrich the setting with autoregressive shocks to capital flows, the current account, and interest rates:

$$FA_t^{NR} = \alpha \left( i_t^F - i_t^H + \mathbb{E}_t e_{t+1} - e_t \right) - z_t$$

$$CA_t = \gamma e_t + \zeta_t$$

$$i_t^H = i_t^F + \delta e_t + \xi_t$$

where:  $z_t = \phi z_{t-1} + \varepsilon_t$ ,  $\zeta_t = \varphi \zeta_{t-1} + \nu_t$ ,  $\xi_t = \psi \xi_{t-1} + \iota_t$ , and  $0 < \phi, \varphi, \psi < 1$ , and  $\mathbb{E}_{t-1} \varepsilon_t = \mathbb{E}_{t-1} \nu_t = \mathbb{E}_{t-1} \iota_t = 0$ .

- Reserves lean against shocks to capital inflows:

$$\Delta R_{t+1} = \theta z_t$$

- Combining the balance of payments elements, and iterating forward (with the transversality condition):

$$e_t = -\frac{1}{1 + \delta - \psi + \frac{\gamma}{\alpha}} \xi_t - \frac{1}{1 + \delta - \varphi + \frac{\gamma}{\alpha}} \frac{\zeta_t}{\alpha} - \frac{1 - \theta}{1 + \delta - \phi + \frac{\gamma}{\alpha}} \frac{z_t}{\alpha}$$

- The reserve policy limits the impact of capital flows shocks.
- Under UIP ( $\alpha \rightarrow \infty$ ), shocks to the current account or capital flows do not impact the nominal exchange rate.

# SOME EMPIRICAL EVIDENCE

# Do interventions work?

- Focus on sterilized interventions are quite common (Fratzscher, et al. 2019).
  - The central bank sells / buys foreign currency assets, offsets with domestic currency assets, no change in money supply.
- Theoretical channels for effectiveness.
  - Portfolio balance: private investors are willing to take the mirror position of the central bank only with different asset prices.
  - Signalling: the intervention conveys information about future policy.
- New database of daily observations for 33 countries from 1995 to 2011.
- Challenge: we never know how the exchange rate would have moved without interventions.



# How do we define success?

- An intervention can have different objectives.
- “Event” criterion: impact the level of the exchange rate.
  - Does the exchange rate move in the intended direction (depreciation of the domestic currency after a foreign currency purchase)?
- “Smoothing” criterion: limit volatility.
  - Is exchange rate volatility lower after the intervention than before (5 days windows)?
- “Stabilization” criterion: keep the exchange rate in a given range.
  - Does the exchange rate remain within a 2 percent band over the next two weeks?
- To assess effectiveness, test whether the criteria is met more often after an intervention than in other times.

- Distinguish between exchange rate regime: floats, broad bands, narrow bands.
- Floaters are successful according to the event and smoothing criteria.
- Broad and narrow bands are successful according to the smoothing criterion.
  - Narrow bands are successful according to the stabilization criteria, but not to a large extent.
- Large interventions are more successful.
- “Oral” interventions (communications by the central banks) help, especially in turbulent markets.
  - Communication occurs in 52 % of the interventions.

- **Floaters** succeed in moving and smoothing the exchange rate.
- **Managed regimes** succeed in smoothing.

TABLE 4—UNCONDITIONAL SUCCESS RATES OF INTERVENTION EPISODES BY REGIME

Regime	Free floater		Broad band		Narrow band	
Criterion	Event (1)	Smooth (2)	Smooth (3)	Stabilize (4)	Smooth (5)	Stabilize (6)
Intervention episodes	0.611	0.883	0.791	0.348	0.781	0.840
Placebo rates	0.481	0.401	0.396	0.495	0.342	0.768
$p$ -value ( $H_0$ : equal effectiveness)	0.012	0.000	0.000	0.000	0.000	0.000
$p$ -value ( $H_0$ : actual $\leq$ placebo)	0.006	0.000	0.000	1.000	0.000	0.000
Actual events	95	77	561	1,062	1,010	2,893

Fratzscher, Marcel, Oliver Gloede, Lukas Menkhoff, Lucio Sarno, and Tobias Stöhr (2019). "When is foreign exchange intervention effective? Evidence from 33 countries", *American Economic Journal: Macroeconomics* 11(1), pp. 132-156.