
Behavioural and Fundamental Equilibrium Exchange Rate of the Czech Koruna

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European Central Bank
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Presentation outline

1. **Motivation and goal**
2. Single equation model – Behavioural Equilibrium Exchange Rate (BEER)
3. Multi-equation model – Fundamental Equilibrium Exchange Rate (FEER)
4. Monetary policy implications
5. Conclusion

The views expressed here are those of the authors and do not necessarily reflect the official position of the Czech National Bank.



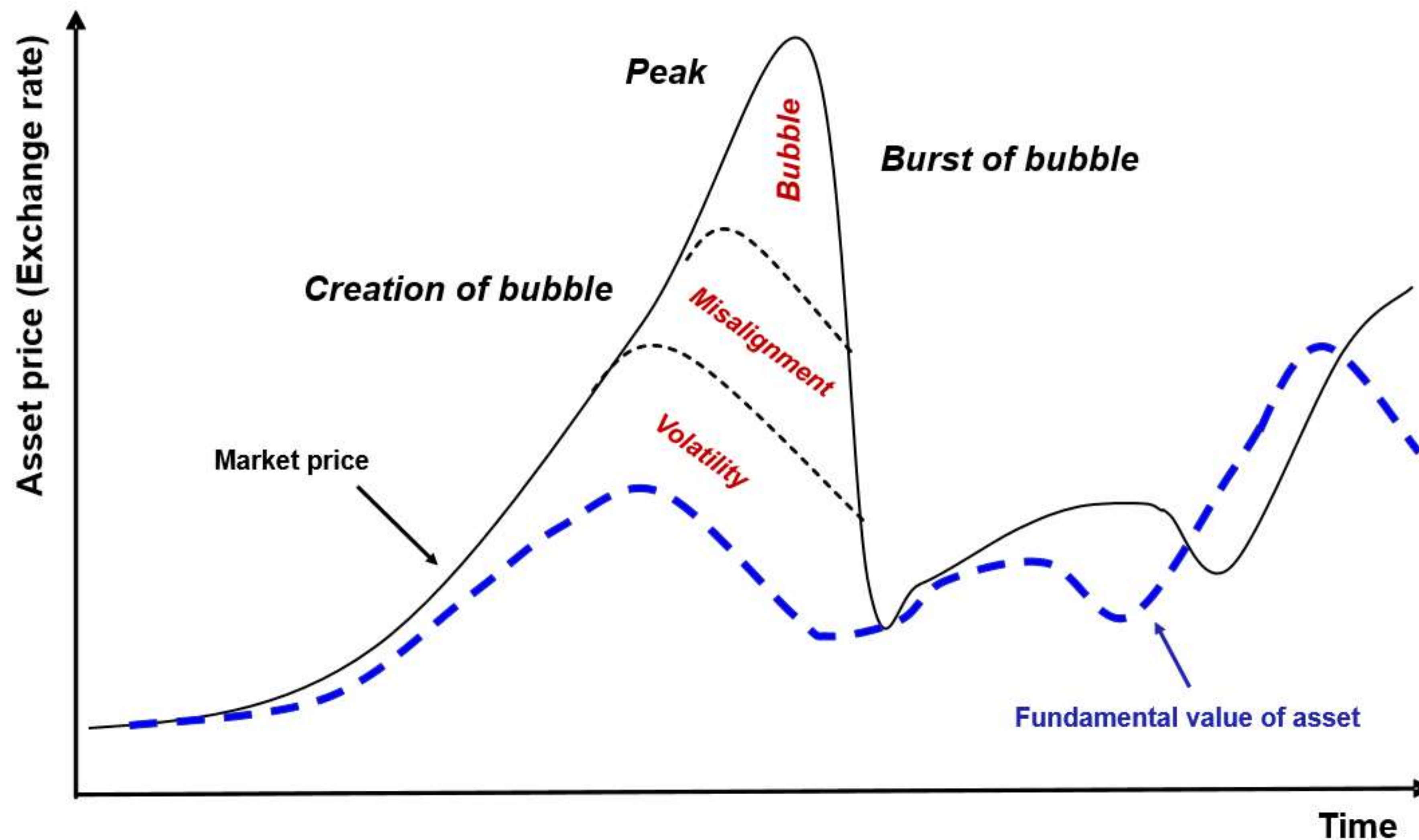
Importance of equilibrium exchange rate estimates for the central bank:

- They provide the additional knowledge the CB needs to conduct independent monetary policy effectively.
- They allow for monitoring and enter the calculation of the exchange rate component of the real monetary conditions.
- They provide information on the evolution of the price competitiveness of the economy, in which the exchange rate plays a decisive role.
- They provide the necessary knowledge of possible exchange rate misalignment in the process of joining the monetary union (euro area), i.e. the determination of the central parity before ERM II entry, or the conversion rate before euro area entry.

ECB (2003): *“The central rate should reflect the best possible assessment of **the equilibrium exchange rate** at the time of entry into the mechanism. This assessment should be based on a broad range of economic indicators and developments while also taking account of the market rate.”*

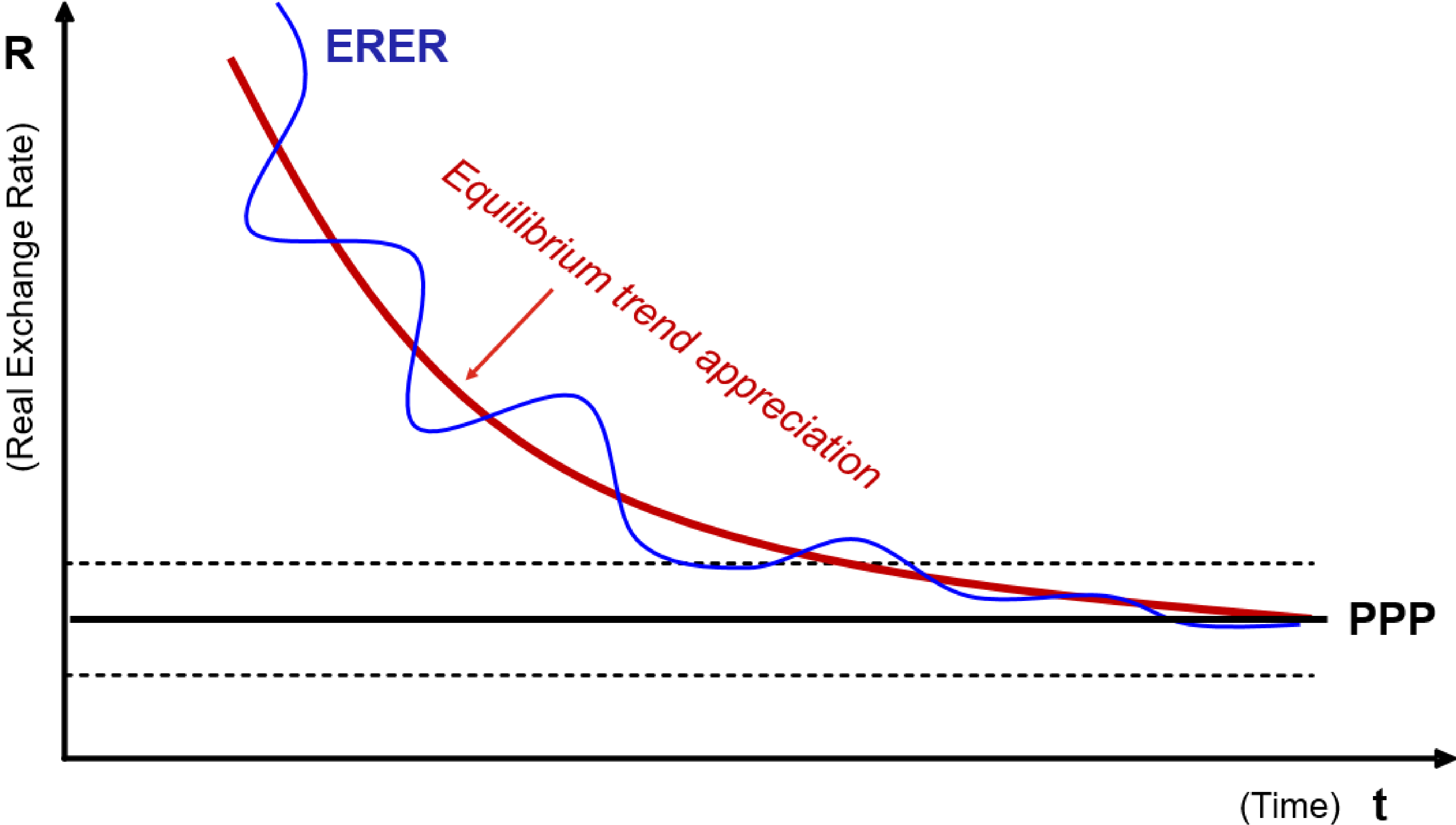
18th December 2003

Volatility, misalignment, bubble...



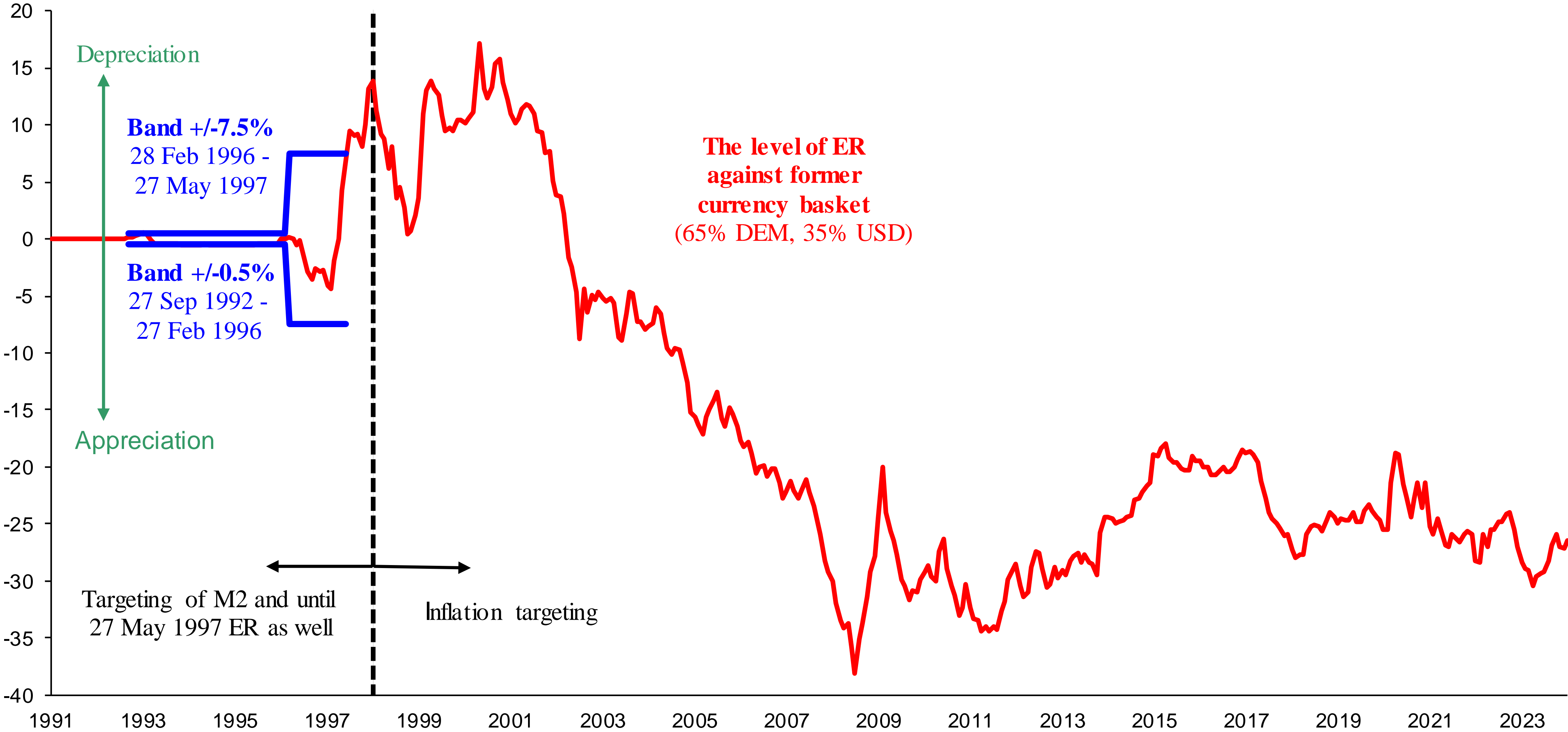
Source: Komarek et al. (2012).

Real appreciation trend and the EREER

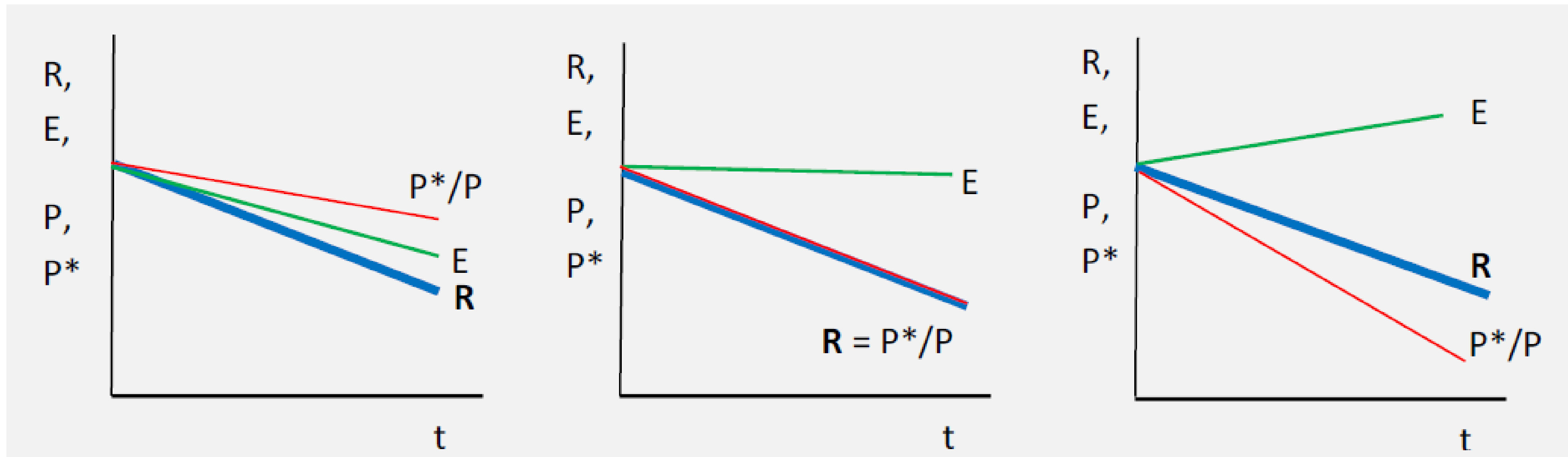


Source: Komarek et al. (2012).

“Life cycle” of the Czech koruna



Real exchange rate: Appreciation variants

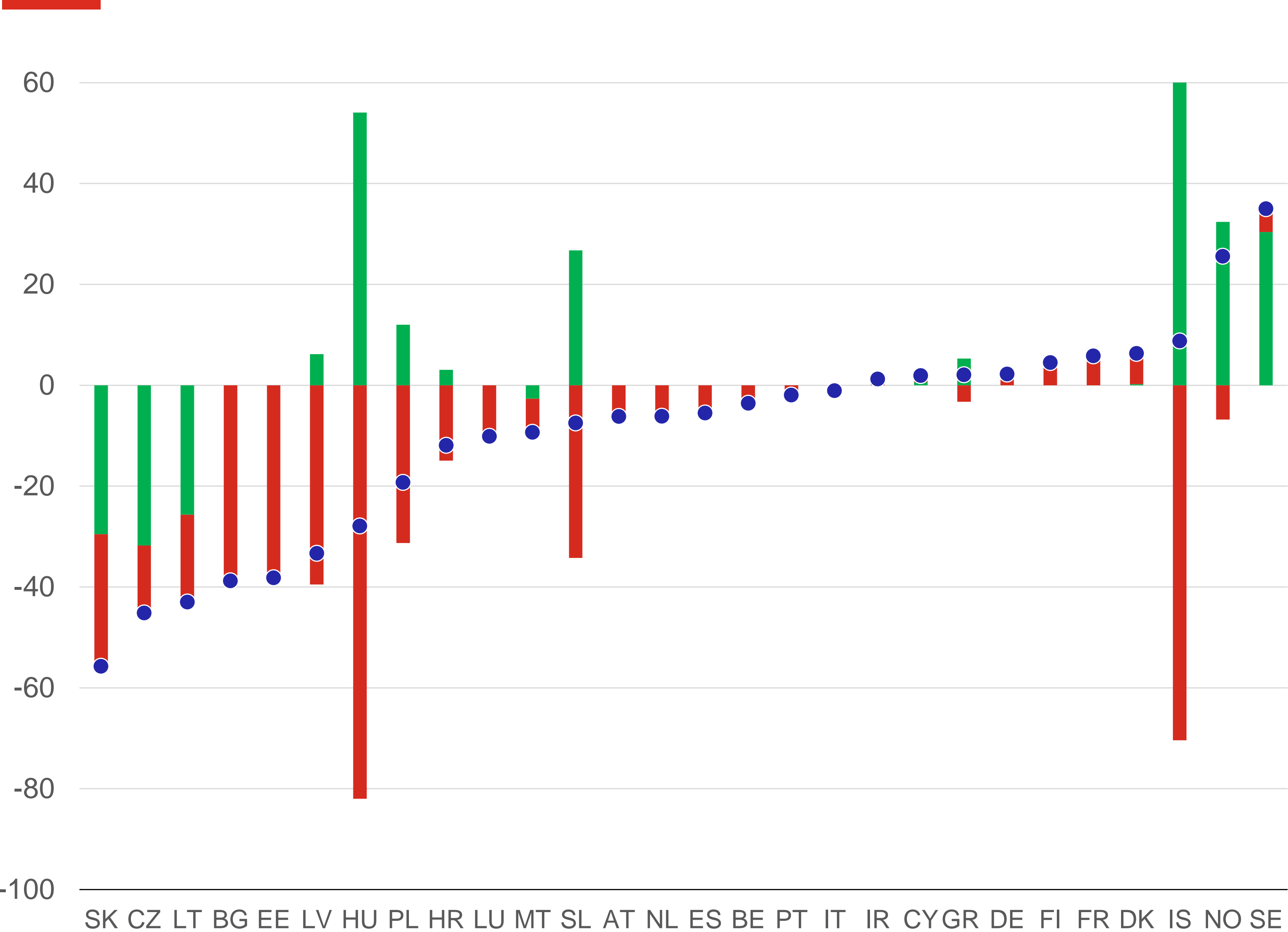


Note: R – real exchange rate, E – nominal exchange rate, P – home price level, P* – foreign price level

The path of the real exchange rate (R) is determined by the movements of its three components: the nominal exchange rate (E), the foreign price level (P*) and the home price level (P).

- If domestic prices go up faster than foreign prices (the ratio of price levels P^*/P falls) and the nominal exchange rate remains unchanged, the real exchange rate falls (the home currency appreciates in real terms).
- If domestic prices go up slower than foreign prices (the ratio of price levels P^*/P rises) and the nominal exchange rate stays unchanged, the real exchange rate rises (the home currency depreciates in real terms).

Real exchange rate in EU countries (1999–2023)



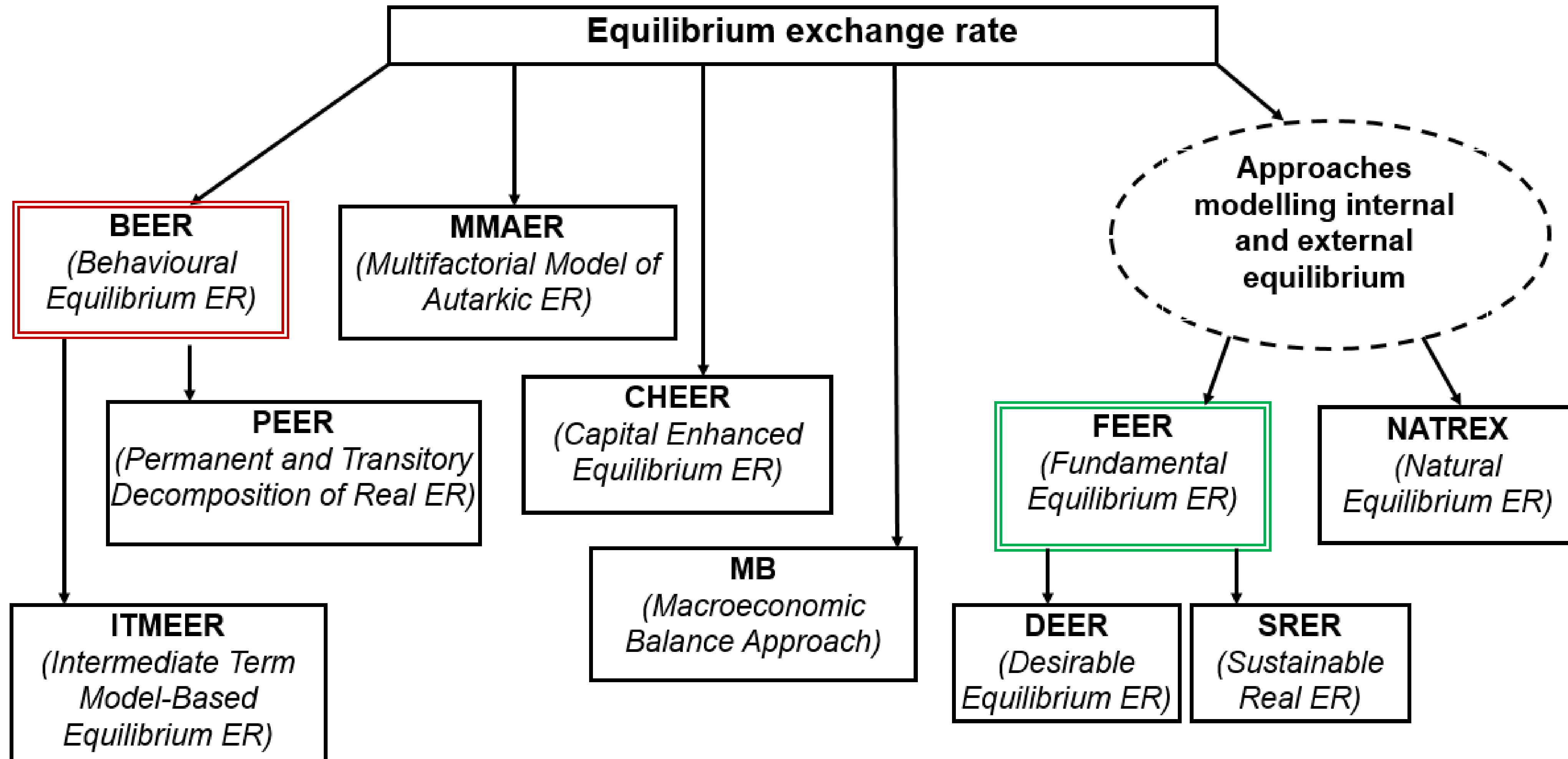
$$R = E \cdot \frac{P^*}{P}$$

- change in real exchange rate
- contribution of change in nominal exchange rate
- contribution of change in relative prices

Equilibrium exchange rate concepts

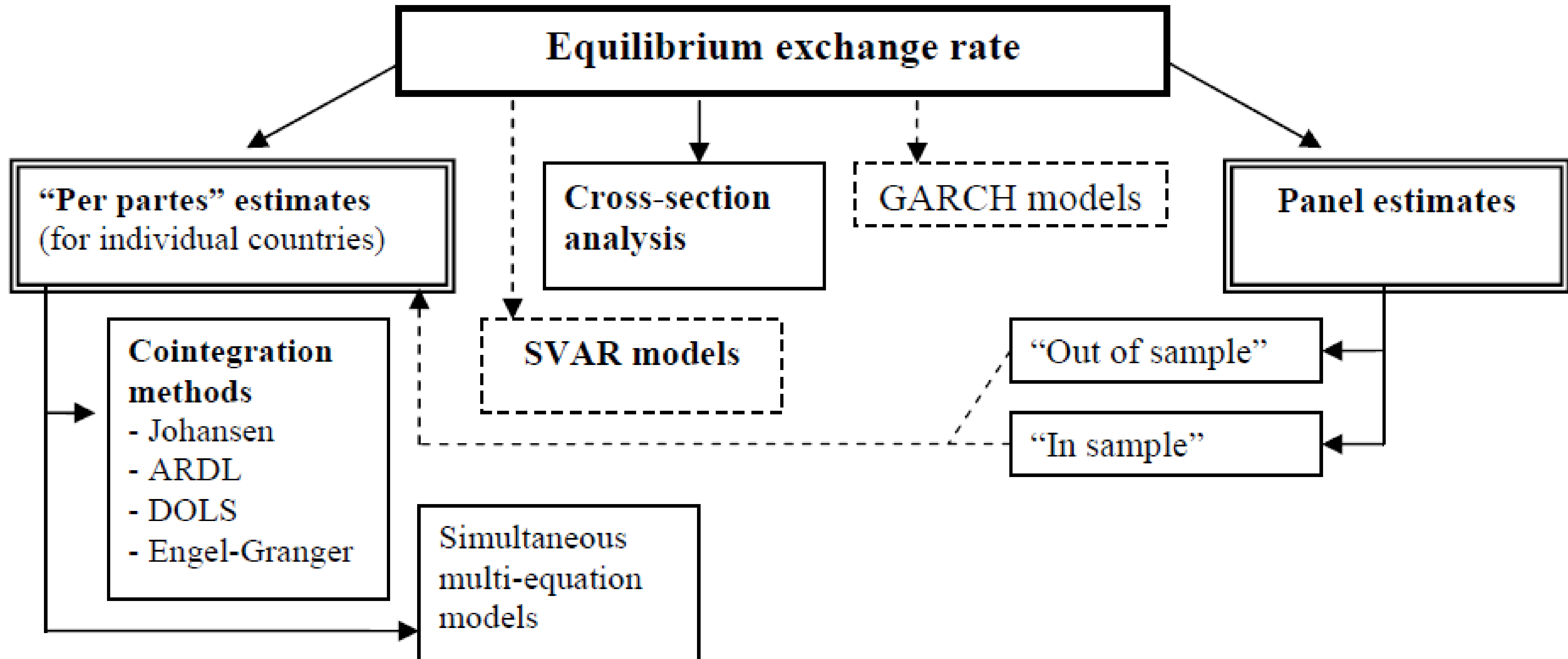
- **Positive approaches** take the current values of variables and current policies and use them to determine the equilibrium future value of the exchange rate.
- **Normative approaches** use not only current variables, but also “desirable” model relationships and trajectories that we would like to achieve.

Equilibrium exchange rate concepts



...but, for example, Driver and Westaway (2004) distinguish up to 14 approaches.

Empirical methods for estimating the EREER



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Behavioural Equilibrium Exchange Rate (BEER)

- The **BEER** approach decomposes the variables that determine the real exchange rate into long-term economic fundamentals and short-term real interest rate differentials.
- The key elements of the **BEER** approach are:
 - (1) a set of long-term economic fundamentals, including, for example, the terms of trade, net foreign assets, relative government debt and productivity, and
 - (2) uncovered interest rate parity (UIP), which is assumed to determine the short-term (cyclical) behaviour of the exchange rate.

1. Productivity and the productivity differential (DPROD)

- **via the “price” channel:** $DPROD \uparrow \Rightarrow$ through Balassa-Samuelson effect $\Rightarrow RER \downarrow$
- **via the “exchange rate” channel:** $DPROD \uparrow \Rightarrow$ economic growth $\uparrow \Rightarrow$ demand for domestic currency relative to foreign currency $\uparrow \Rightarrow RER \downarrow$

Overall: An **increase in productivity** should result in an **appreciation** of the RER.

2. Net foreign assets (NFA)

- $NFA \uparrow \Rightarrow \text{domestic income} \uparrow \Rightarrow \text{expenditure on domestic goods} \uparrow \Rightarrow P_{NT} \uparrow \Rightarrow \text{domestic prices } (p) \uparrow \Rightarrow RER \downarrow$
- The NFA channel is also a traditional part of the UIP condition in structural models for open economies, i.e. when investors perceive an improvement in NFA, they require a lower risk premium, which ceteris paribus leads to a strengthening of the exchange rate ($RER \downarrow$).

Overall: An **increase in NFA** should result in an **appreciation** of the RER.

3. Foreign direct investment (FDI)

- **via financial account:** $FDI \uparrow \Rightarrow \text{supply of foreign currency} \uparrow \Rightarrow NER \downarrow$ and $RER \downarrow$
- **via “productivity” and “price” channel:** $FDI \uparrow \Rightarrow \text{productivity} \uparrow \Rightarrow RER \downarrow$

Overall: An **increase in FDI** should result in an **appreciation** of the RER, but the outcome may be different in the longer run (profit outflows).

4. Openness (OPEN)

- **openness as a liberalisation phenomenon:**

trade \uparrow \Rightarrow productivity \uparrow (capital accumulation and potential output \uparrow) \Rightarrow RER \downarrow

- **openness as a country risk phenomenon:**

more open economy \Rightarrow smaller country risk

Small open economies in the EU: higher openness (especially due to trade liberalisation \wedge lower country risk) should lead to an appreciation of the RER. However, the transformation aspect is gradually decreasing.

Overall: An **increase in trade** should result in an **appreciation** of the RER.

5. Terms of trade (TOT)

- **endogenous improvement:**

$TOT \uparrow \Rightarrow P_{ex} \uparrow$ (due to quality improvement) \Rightarrow domestic prices $(p) \uparrow \Rightarrow RER \downarrow$

- **exogenous improvement:**

$TOT \uparrow \Rightarrow$ because of positive shock to TOT (decrease in raw materials prices) \Rightarrow substitution effect (firms produce more exportable and fewer non-tradable goods) $\Rightarrow AS \uparrow \Rightarrow w_T \uparrow \wedge w_{NT} \uparrow \Rightarrow P_{NT} \uparrow \Rightarrow$ domestic prices $(p) \uparrow \wedge CA$ (improves) $\Rightarrow RER \downarrow$ (if country mainly imports raw materials)

Overall: An **increase in the TOT** should result in an **appreciation** of the RER.

6. Real interest rate differential (RIRD)

- $RIRD \uparrow \Rightarrow$ demand for domestic assets $\uparrow \Rightarrow RER \downarrow$ (currently), but also indicates (according to UIP condition) depreciation expectations in future.
- **More complex view:** Growth in absorption relative to savings \Rightarrow upward pressure on RIR (if capital mobility is not perfect) \Rightarrow demand for T and $NT \uparrow \Rightarrow RER \downarrow$

Overall: An **increase in the RIRD** should result in an **appreciation** of the RER.

7. Government spending (GS)

- **in the short run:** $GS \uparrow \Rightarrow$ public consumption \uparrow (due to higher share of NT goods in public consumption relative to private consumption) \Rightarrow demand for NT goods $\uparrow \Rightarrow P_{NT} \uparrow \Rightarrow$ domestic prices $(P) \uparrow \Rightarrow RER \downarrow$
- **in the long run (medium run):** $\Sigma GS \uparrow \Rightarrow$ budget deficit $\uparrow \Rightarrow$ possible destabilisation of economy (if current $GS >$ sustainable $GS \approx$ Maastricht debt criterion) $\Rightarrow RER \uparrow$

Overall: An **increase in GS** should usually result in an **appreciation** of the RER.

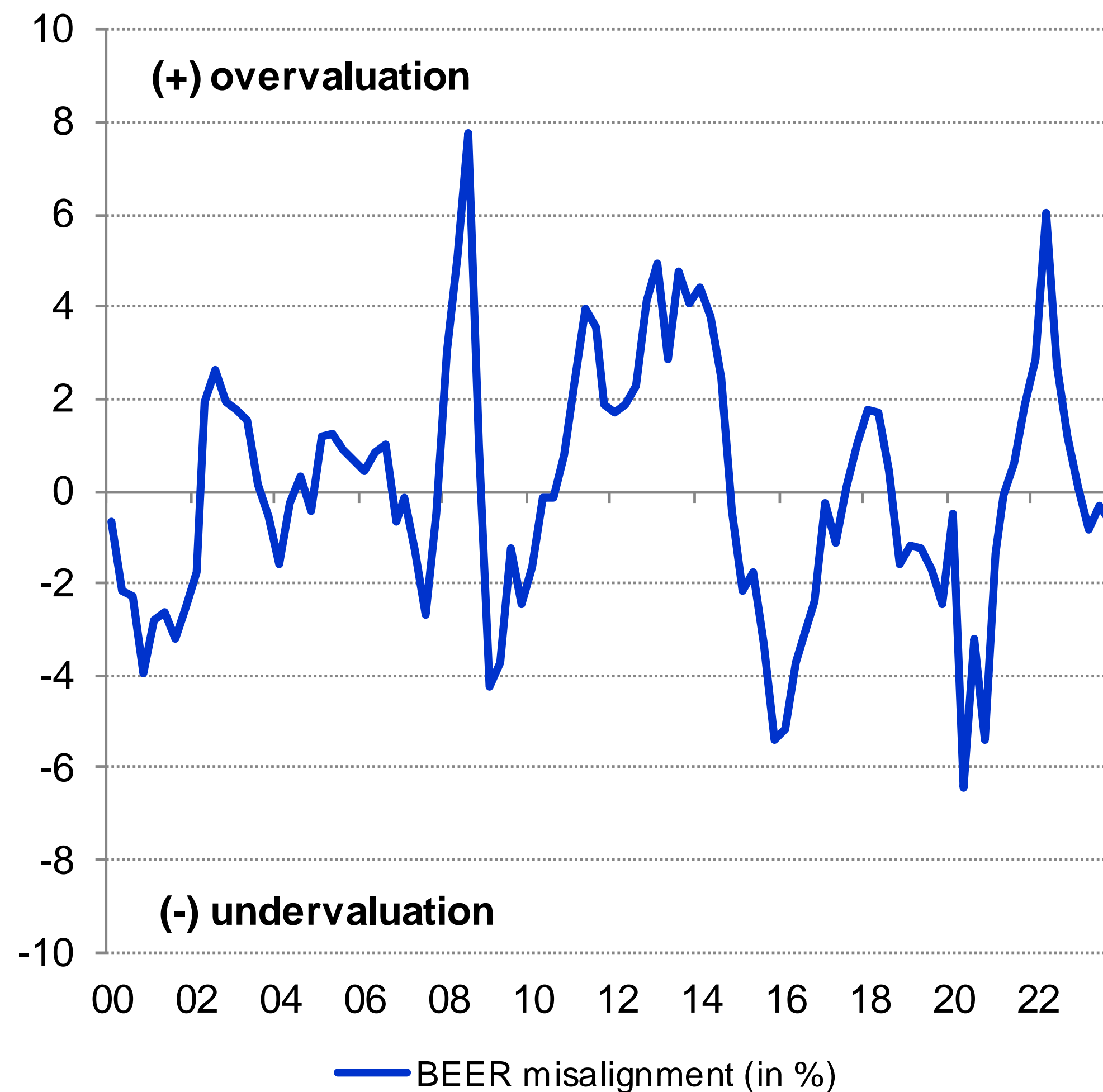
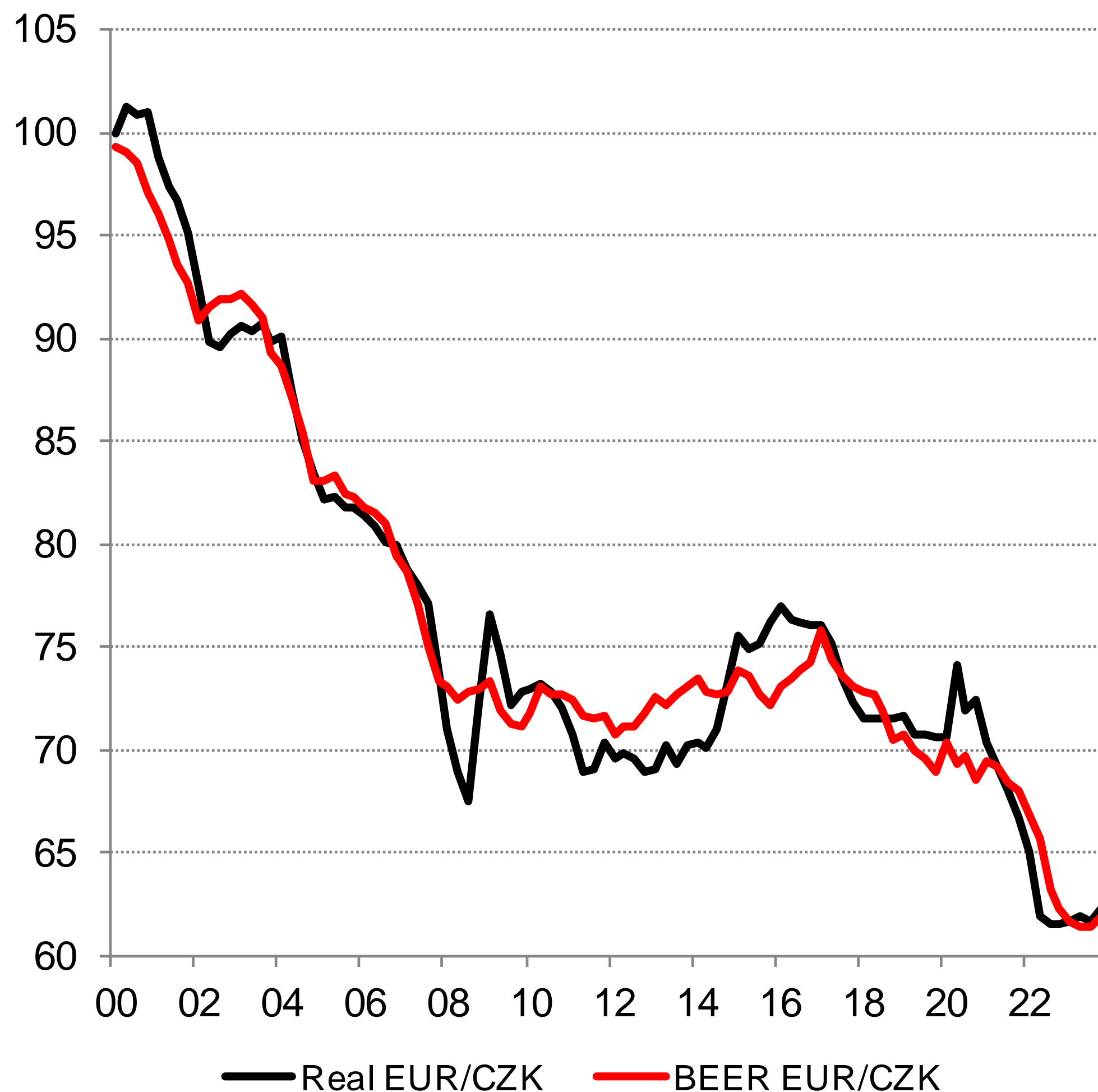
Behavioural Equilibrium Exchange Rate (BEER)

RER = f (**fundamental variables** affecting real exchange rate)

$$\text{RER}_t = \text{DPROD}_t + \text{NFA}_t + \text{THFK}_{t-1} + \text{NX}_t + c$$

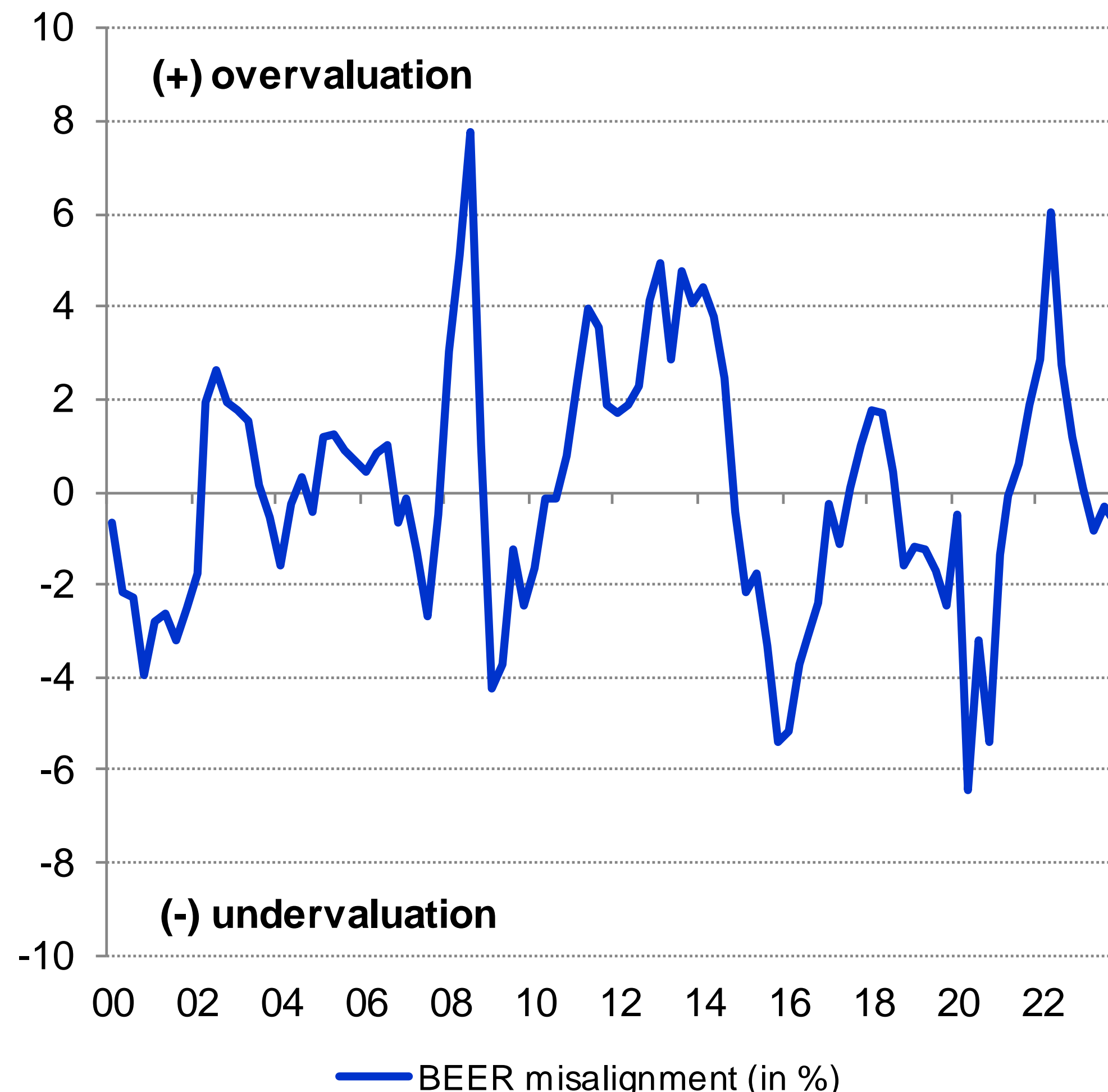
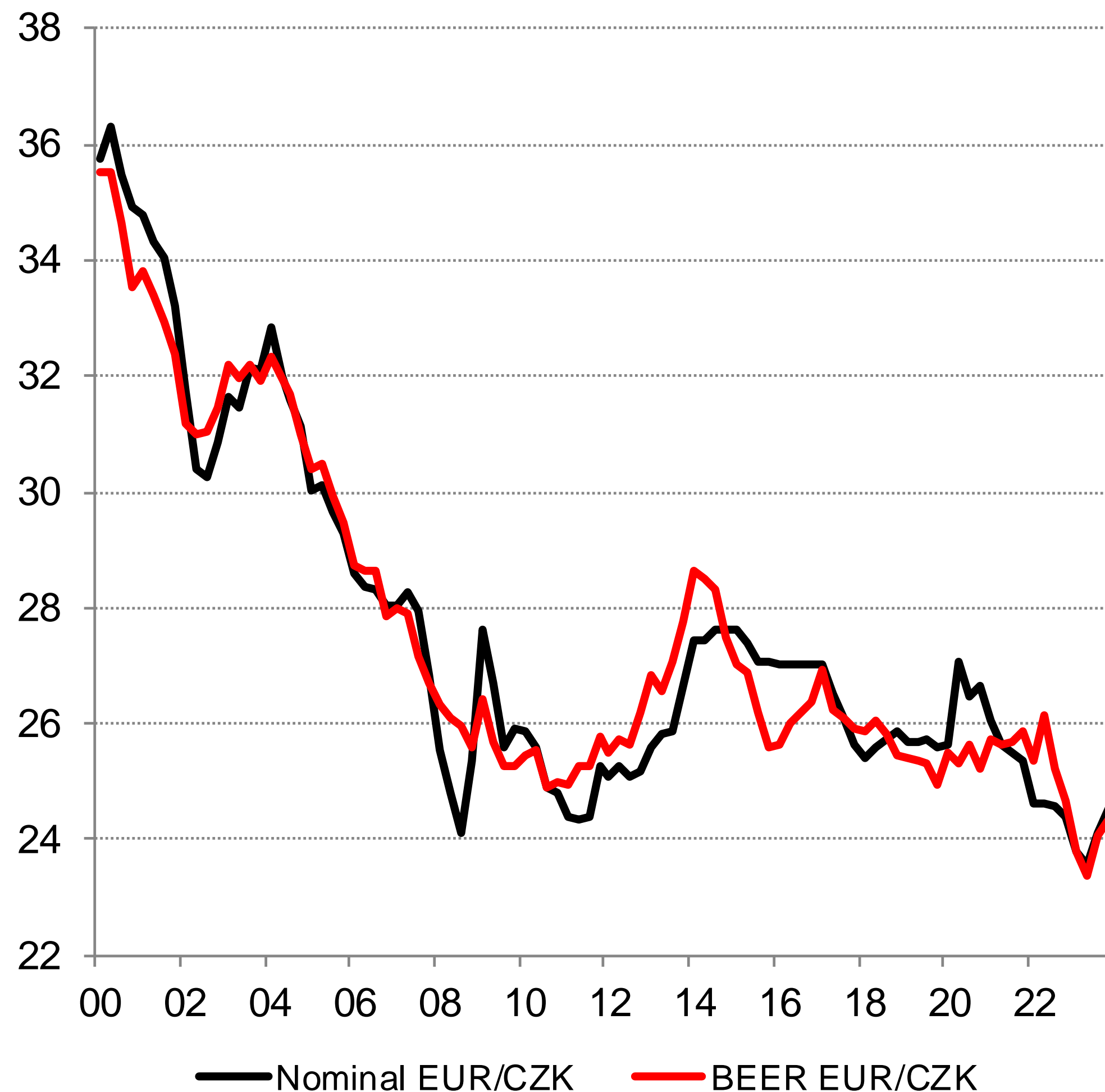
- RER – real exchange rate (deflated by PPI in manufacturing)
- DPROD – differential in productivity between CZ and EA
- NFA – net foreign assets over GDP
- THFK – real investment over GDP
- NX – net exports over GDP

BEER – Estimate and misalignment (in real terms)



Note: The chart on the left displays the estimate of the BEER path. The chart on the right shows the misalignment of the BEER.

BEER – Estimate and misalignment (in nominal terms)



Note: The chart on the left displays the estimate of the BEER path, recalculated from real to nominal terms using the PPI differential in manufacturing. The chart on the right shows the misalignment of the BEER.

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Fundamental Equilibrium Exchange Rate (FEER)

- The **FEER** is defined as the exchange rate that is consistent with both internal and external balance simultaneously (Williamson, 1994).
- **Internal balance** is reached when the economy in question is at the full-employment level of output at stable prices, while **external balance** is characterised as the current account being at a sustainable level over the medium term.

FEER – Partial equilibrium approach

- Based on a simple foreign trade model and exogenous internal and external balance of the economy.

Foreign trade block: $X = f(\text{FD}, \text{RER}, \text{DPROD})$

$$M = f(D, \text{RER}, X)$$

$$CA = X - M$$

Internal balance: $Y = Y^{\text{IB}}$

External balance: $CA = CA^{\text{EB}}$

FEER: $Y - Y^{\text{IB}} \cap CA - CA^{\text{EB}} = 0$

$$Y^{\text{GAP}} \cap CA^{\text{GAP}} = 0$$

FEER – Foreign trade block (export and import equation)

$$\ln(X_t) = \ln(FD_t) + \ln(RER_t) + (DPROD_t) + c$$

X – real exports of goods and services

FD – foreign demand

RER – real exchange rate (deflated by PPI in manufacturing)

DPROD – differential in productivity between CZ and EA

$$\ln(M_t) = \ln(D_t) - \ln(RER_t) + \ln(X_t) + c$$

M – real imports of goods and services

D – domestic demand

RER – real exchange rate (deflated by PPI in manufacturing)

X – real exports of goods and services

- Export and import equations represent long-run parts of cointegration vectors estimated by VECMs.

FEER – Internal and external balance identities

$$NX_t = X_t - M_t \quad (1) \quad CA^{EB}_t = CA^{EQ}_t * Y^N_t \quad (5)$$

$$Y_t = D_t + NX_t \quad (2) \quad NX^N_t = P^X_t * NX_t + M_t (1 - P^M_t / P^X_t) * P^X_t \quad (6)$$

$$Y^{GAP}_t = Y_t - Y^{IB}_t \quad (3) \quad CA^{GAP}_t = NX^N_t - CA^{EB}_t \quad (7)$$

$$Y^N_t = Y_t * P^Y_t \quad (4)$$

CA^{EB} – sustainable level of current account at current prices

CA^{EQ} – sustainable level of CA/GDP in % (obtained by filtering CA/GDP data adjusted for net capital flows from EU after accession of CZ in 2004)

CA^{GAP} – deviation of CA from external equilibrium

D – real domestic demand

NX^N, NX – nominal and real net exports of goods and services

Y^N, Y – nominal and real GDP

Y^{GAP} – deviation of GDP from internal balance

Y^{IB} – potential GDP (Cobb-Douglas production function)

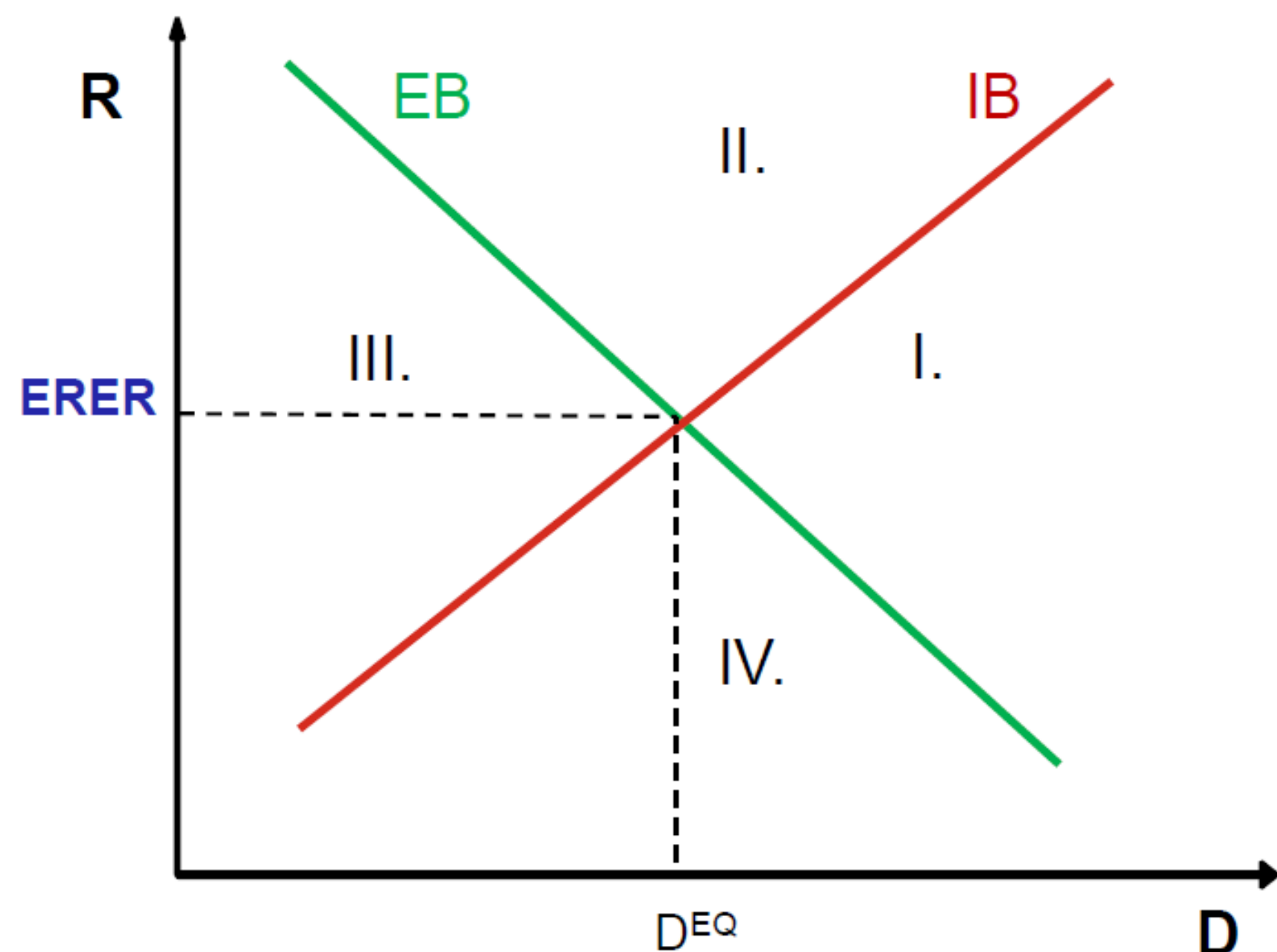
P^Y, P^M, P^X – GDP deflator, import deflator, export deflator

X – real exports of goods and services

M – real imports of goods and services

- Identities serve to simultaneously achieve IB and EB relating to the targeted levels of: $Y^{GAP} \cap CA^{GAP} = 0$ by tool variables: RER and domestic demand.

FEER – Economic equilibrium optimisation approach

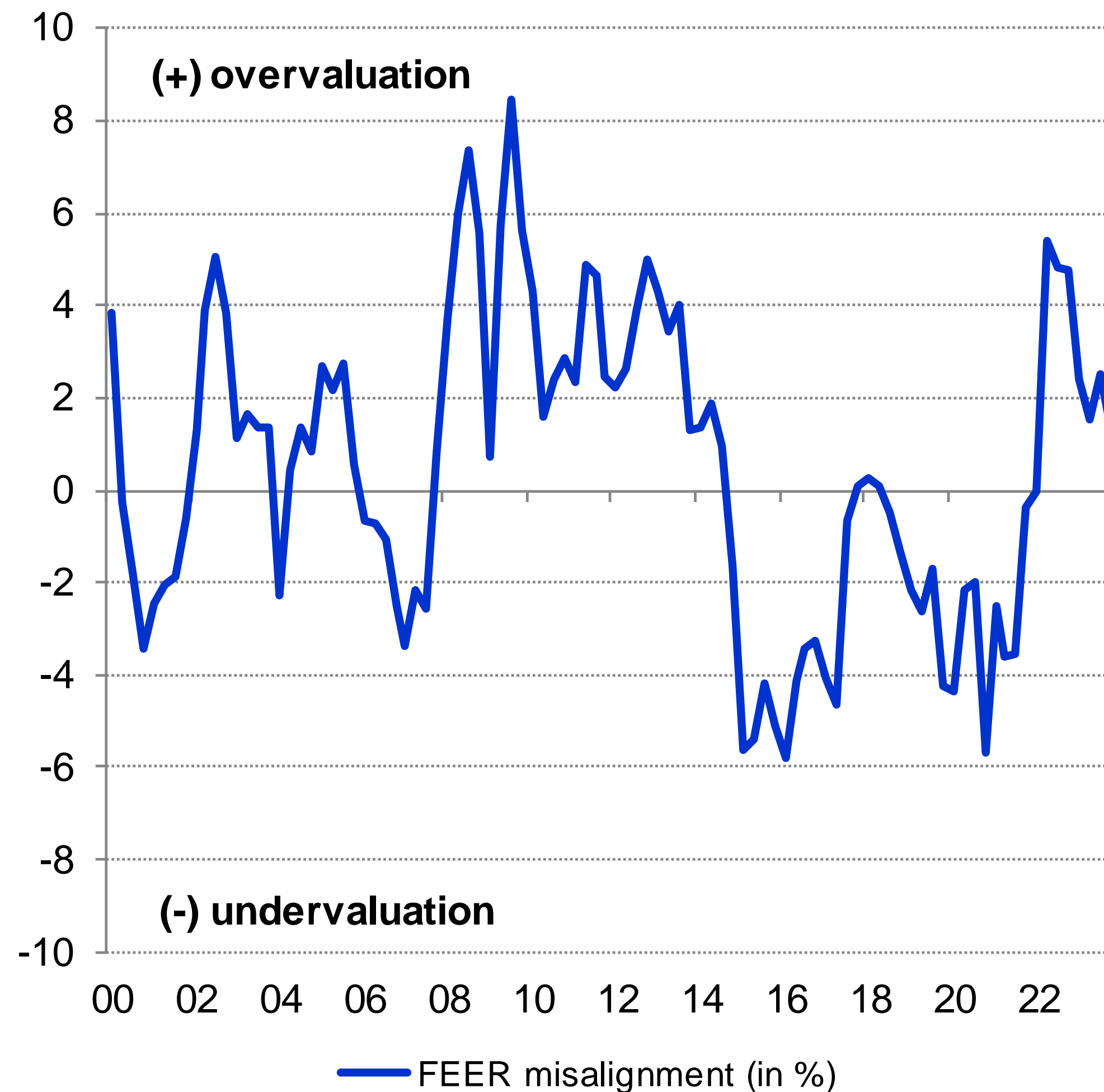
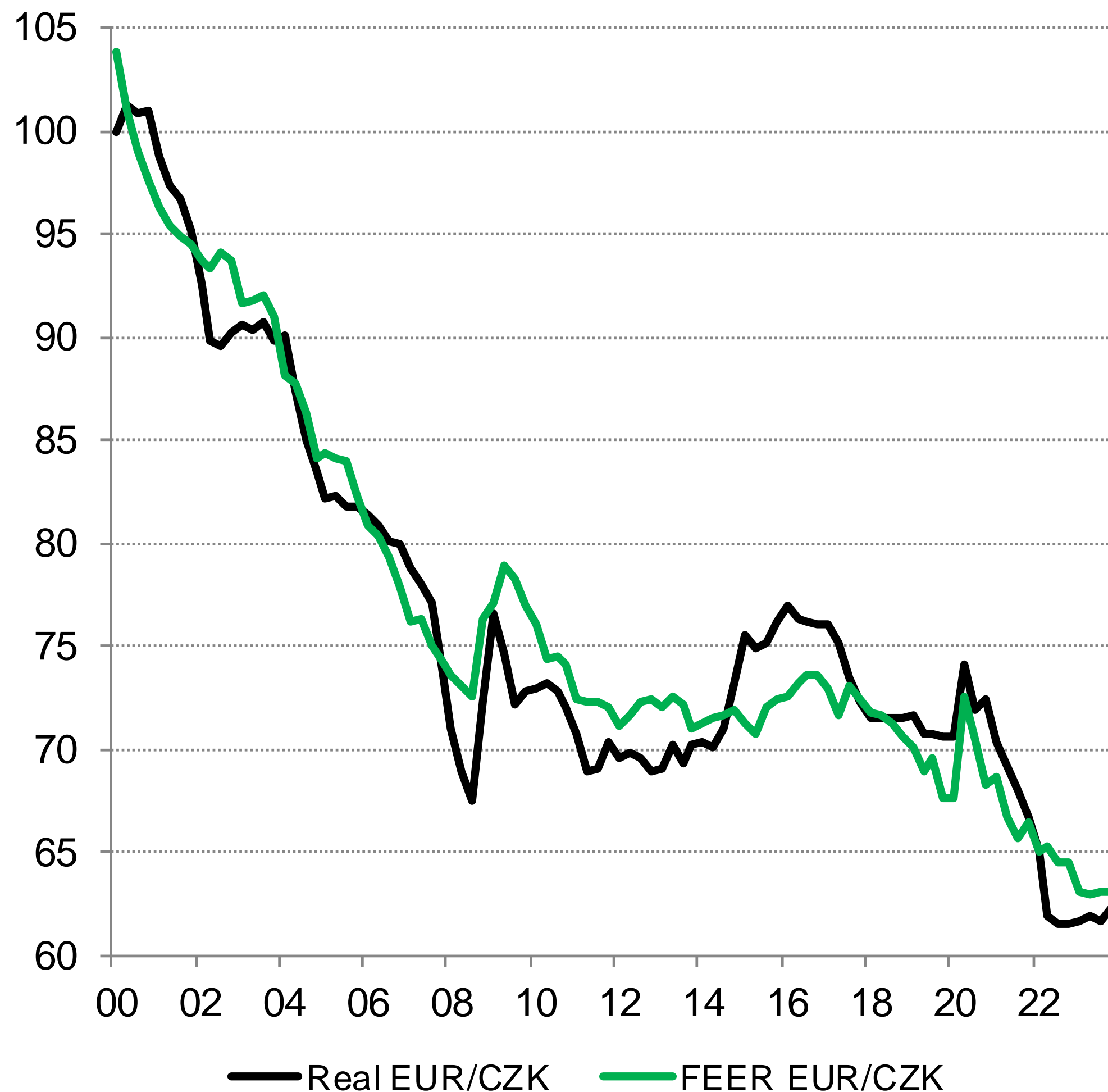


- IB – internal balance (Y^{IB})
- EB – external balance (CA^{EB})
- R – real exchange rate (appreciation \uparrow)
- ERER – equilibrium real exchange rate
- D – domestic demand
- D^{EQ} – equilibrium domestic demand

- I. Positive output gap ($Y^{GAP} > 0$) and CA deficit ($CA^{GAP} < 0$) relative to target $\Rightarrow D \downarrow \cap R \downarrow$
- II. Negative output gap ($Y^{GAP} < 0$) and CA deficit ($CA^{GAP} < 0$) relative to target $\Rightarrow D \uparrow \cap R \downarrow$
- III. Negative output gap ($Y^{GAP} < 0$) and CA surplus ($CA^{GAP} > 0$) relative to target $\Rightarrow D \uparrow \cap R \uparrow$
- IV. Positive output gap ($Y^{GAP} > 0$) and CA surplus ($CA^{GAP} > 0$) relative to target $\Rightarrow D \downarrow \cap R \uparrow$

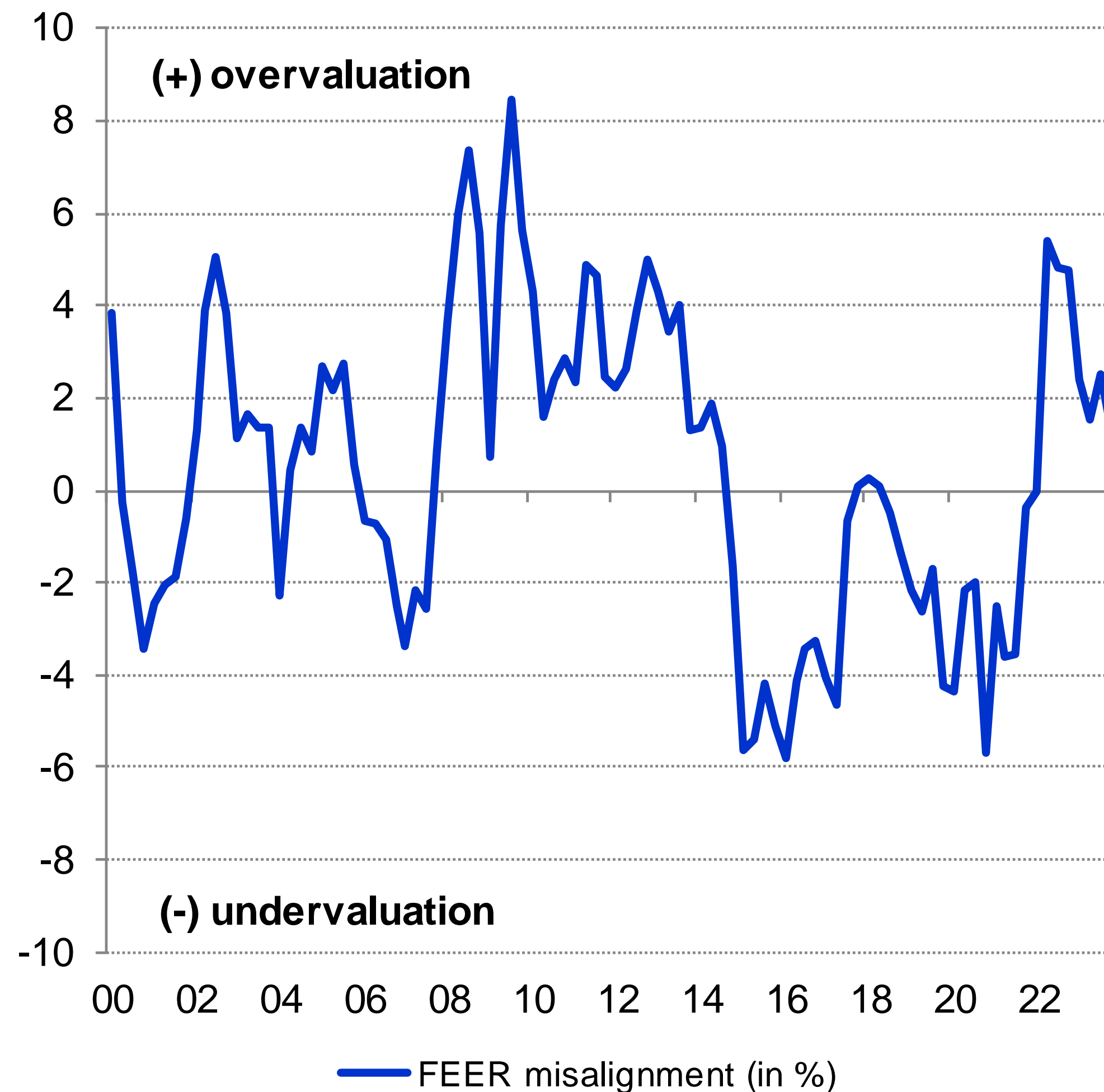
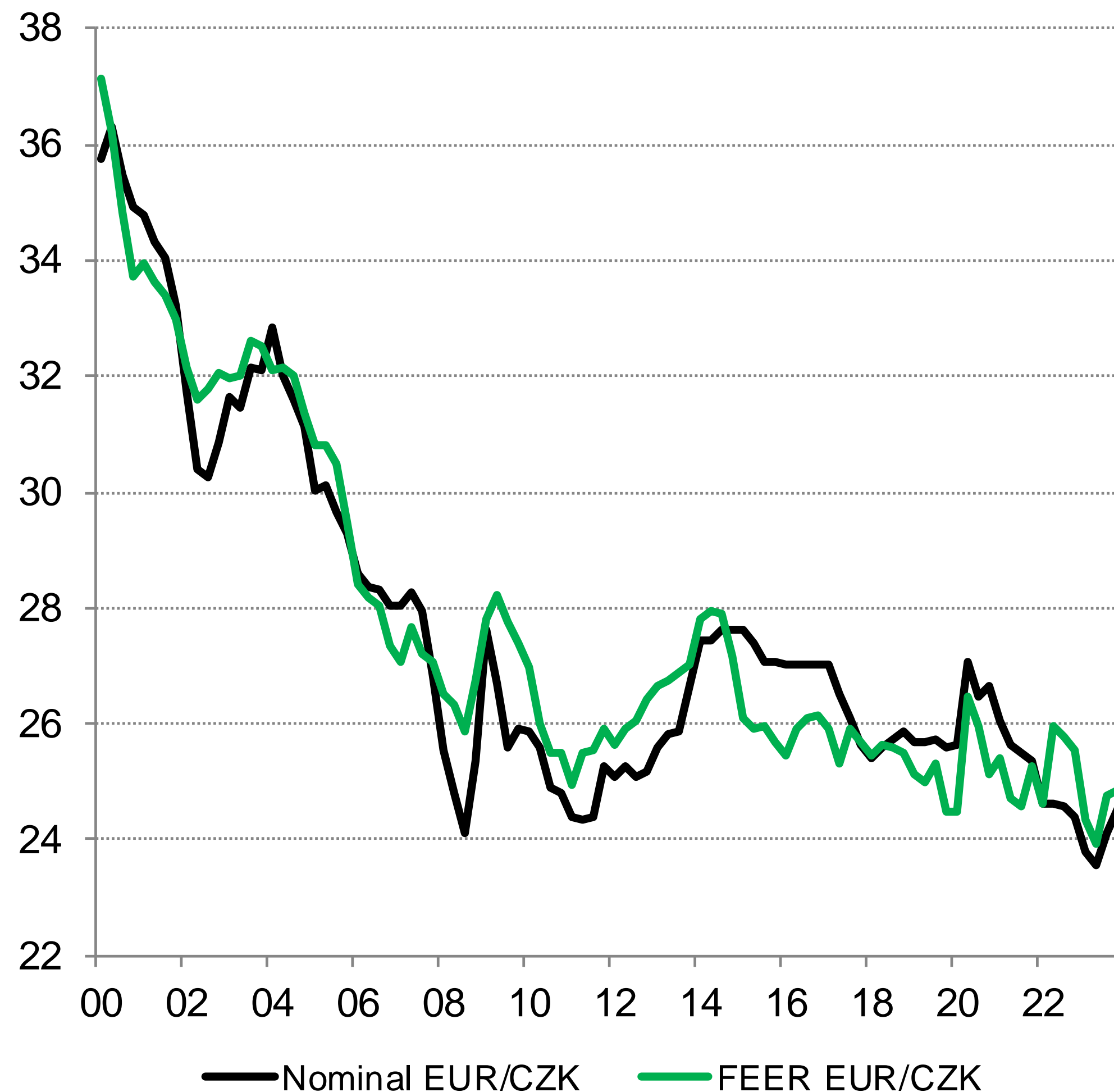
- Changes in potential output (Y^{IB}) and the sustainable level of the current account (CA^{EB}) shift the internal and external balance curves and determine the equilibrium exchange rate path.

FEER – Estimate and misalignment (in real terms)



Note: The chart on the left displays the estimate of the FEER path. The chart on the right shows the misalignment of the FEER.

FEER – Estimate and its misalignment (in nominal terms)



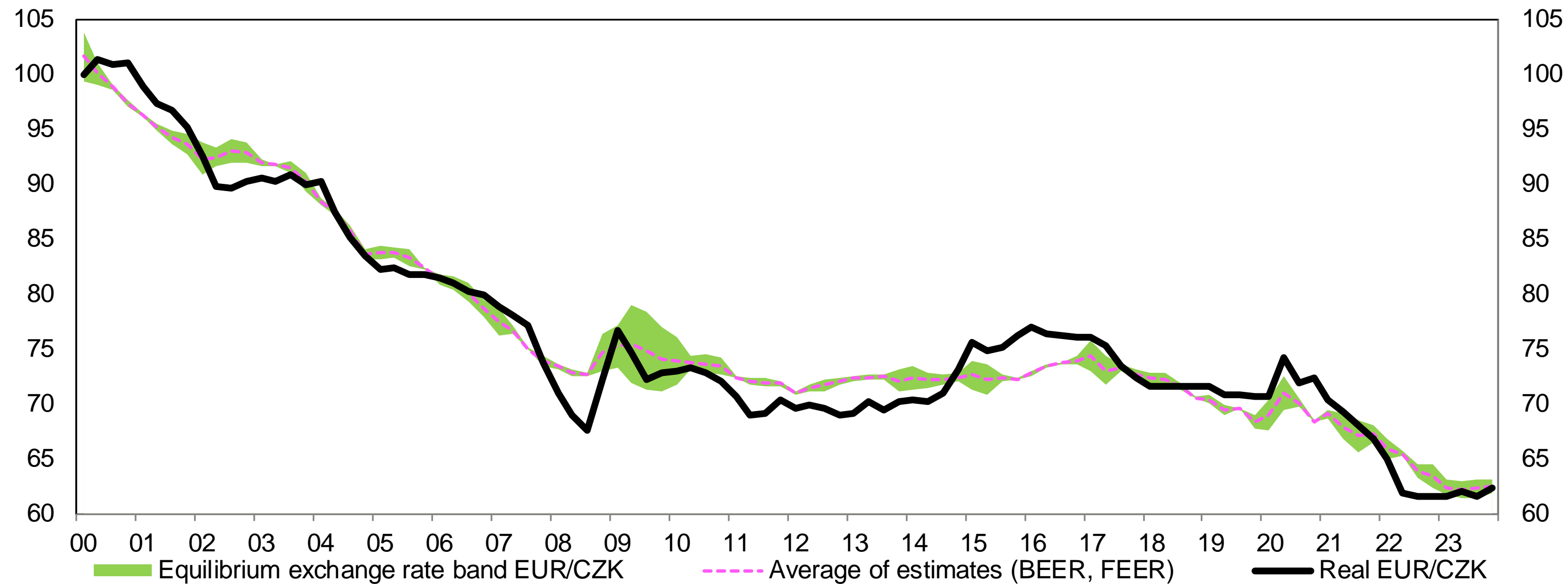
Note: The chart on the left displays the estimate of the FEER path, recalculated from real to nominal terms using the PPI differential in manufacturing. The chart on the right shows the misalignment of the FEER.

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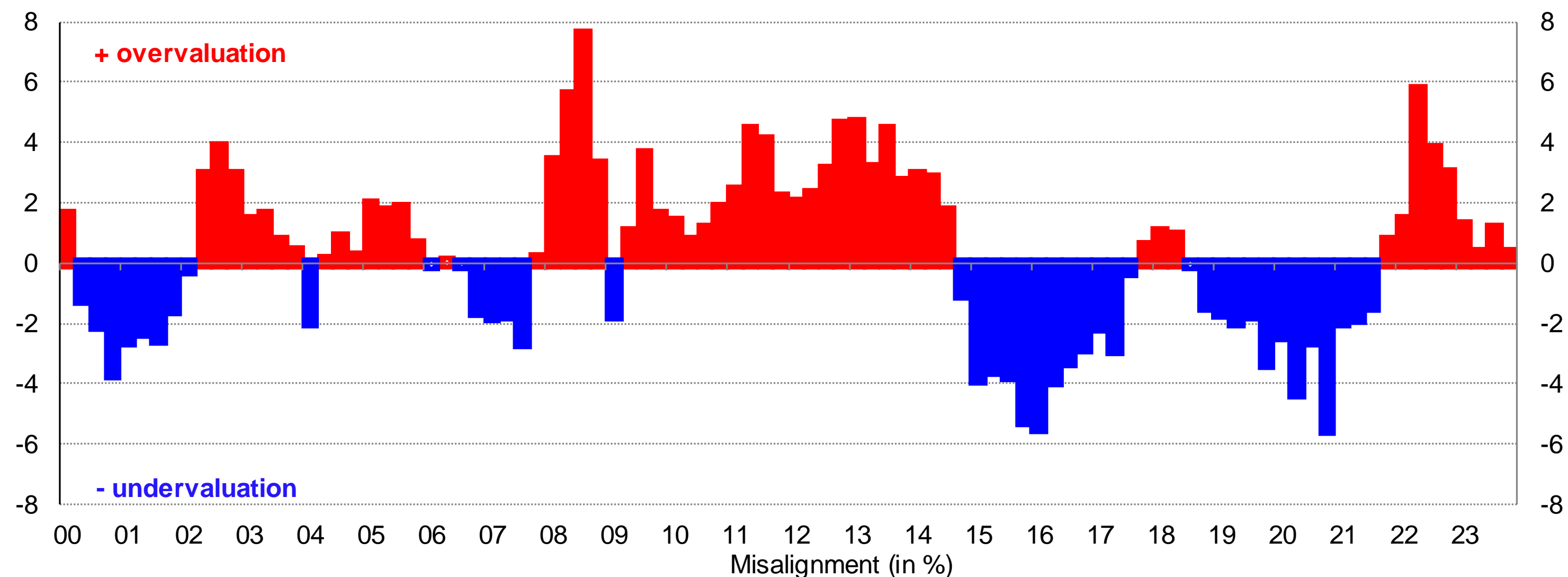
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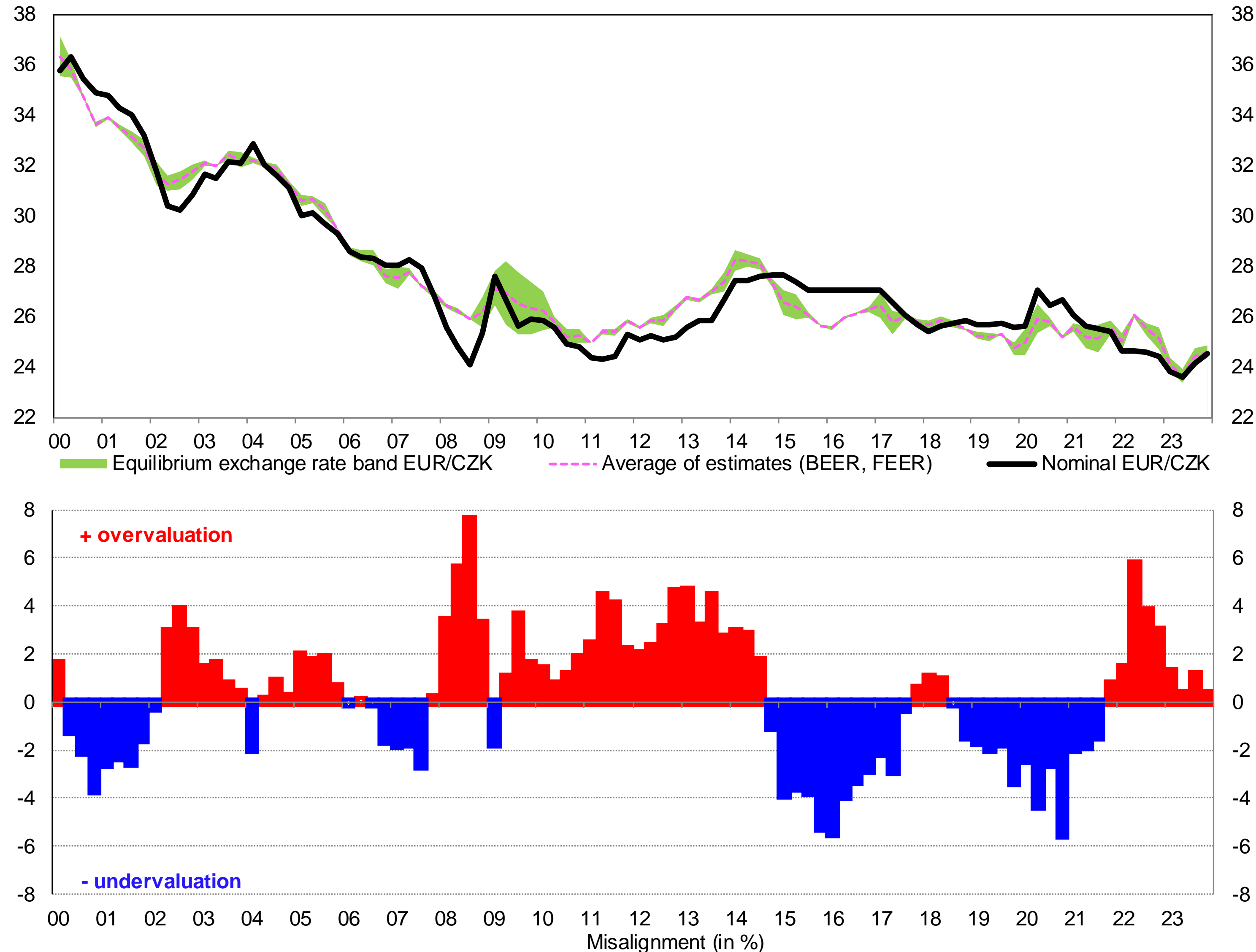
Equilibrium exchange rate band (in real terms)



- The equilibrium exchange rate band is obtained as the range of the estimates according to the BEER and FEER models.



Equilibrium exchange rate band (in nominal terms)



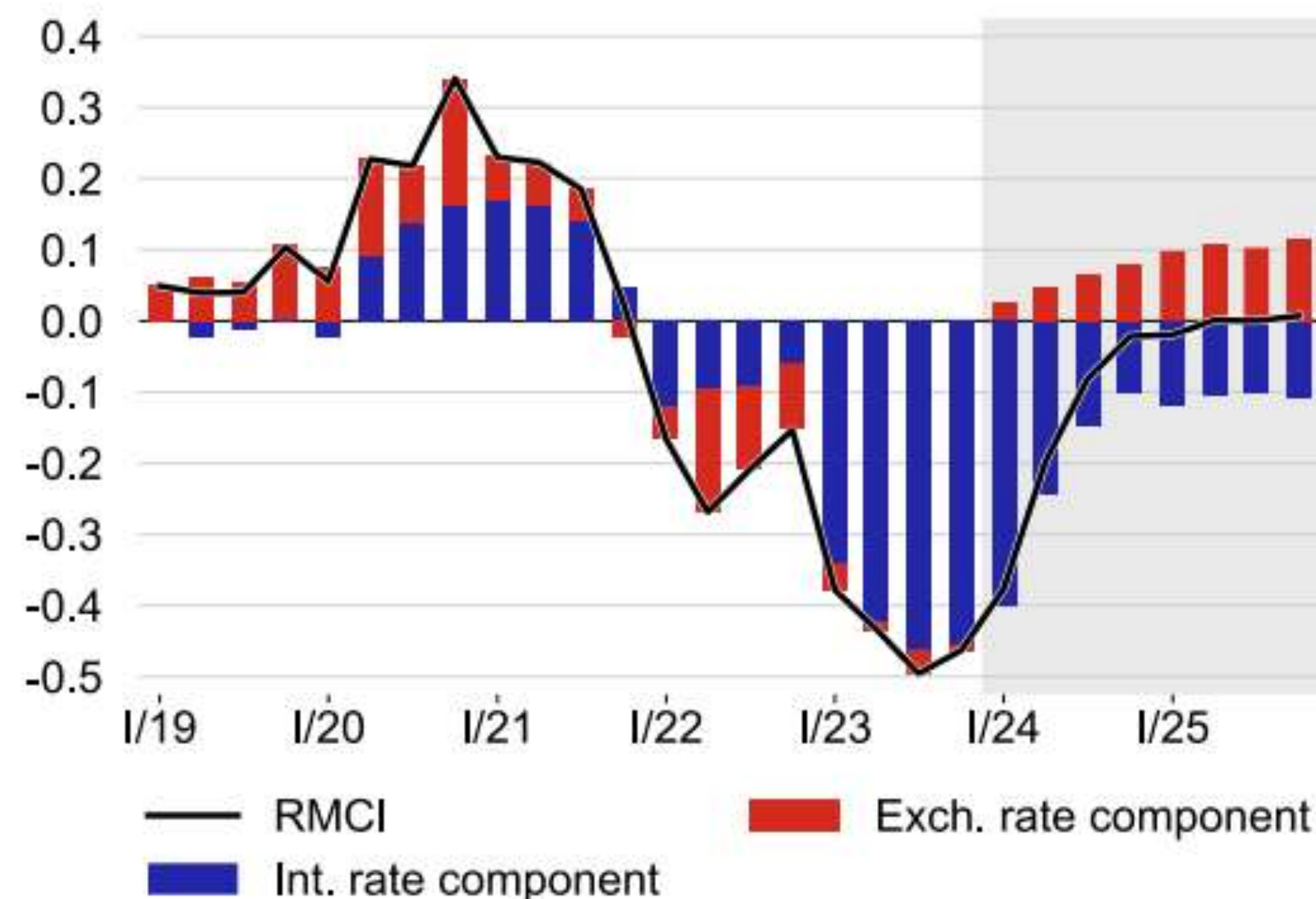
- The equilibrium exchange rate band is obtained as the range of the estimates according to the BEER and FEER models.
- Recalculated from real to nominal terms using the PPI differential in manufacturing.

The EREER as a component of the RMCI

- The deviations of ex ante real interest rates and the real exchange rate from their equilibrium levels enter the real monetary conditions index.

Real monetary conditions index (RMCI)

index; positive (negative) values correspond to easy (tight) monetary conditions



- After having been restrictive for some time, the exchange rate component of the real monetary conditions is now expansionary this year. This is due to the forecasted only slight strengthening of the koruna, which lags behind the equilibrium rate of real appreciation.
- The eased exchange rate component of the monetary conditions helps the domestic economy – hit by low external and domestic demand (as well as fiscal restriction starting this year) – return to growth and, along with the declining domestic interest rates, counteracts an undershooting of the inflation target in the future.

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Conclusion

- Important analysis, especially for a small open economy.
- Potential to identify misalignment, i.e. overvaluation/undervaluation of the domestic currency.
- Economic theory offers a variety of methods to find the equilibrium levels of exchange rates. We employ two of the most frequently used ones at the CNB: BEER and FEER.
- The two models, though based on different model mechanisms and assumptions, give relatively similar results supporting economic intuition regarding periods of overvaluation and undervaluation of the exchange rate of the Czech koruna against the euro.
- Estimates of the equilibrium exchange rate provide decision makers with useful information regarding the effect of the exchange rate as one of the components of the monetary conditions and thus provide guidance in the monetary policy decision-making process.
- The real exchange rate and its position in relation to equilibrium mainly determine the price competitiveness of the economy. It is therefore also a key parameter in the process of preparation for the future fixing of the nominal exchange rate upon entry into the monetary union (euro area).

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Thank you for your attention

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