The effect of the nominal exchange rate on prices: a 2-sector dynamic model with slow capital adjustment and money-in-the-utility

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Model objectives

- basic assumptions:
  - two sectors (traded = manufacturing, nontraded = services), $p_T=ep_T*$
  - two factors of production (capital and labor)
  - slow adjustments (from intertemporal behavior): nominal -- consumption expenditures and income (MIU); real -- K accumulation (q)
- its behavior: effects of shocks (nominal, real), nominal paths
  - prices, wages, rental rates
  - capital and labor employment in the two sectors
  - consumption, investment, trade balance
  - impact effect plus persistence -- an endogenous propagation mechanism: excess demand (spending) creates *some* of its excess supply (income)
  - both rigidities are needed for both the impact effect and the persistence
- *highlights that open economy real exchange rate developments have deep 2-sector, 2-factor determinants*

Potential applications

- demand effect of a fiscal (income) shock: income $\uparrow$ => expenditure $\uparrow$ => NT-T relative price $\uparrow$ => income (w) $\uparrow$
- nominal appreciation: reproduces quite many of stylized ERBS facts (Reinhart-Végh 1995, Burnstein et al 2002) and the recent Hungarian experience, *without sticky prices*
  - (1-2) consumption boom, (3) slow disinflation, (4) trade deficits
  - NT prices and wages are major sources of inflation "misbehavior"
  - investment collapse, FDI outflow, T-NT asymmetry in investment
- the effect is like a fiscal expansion! => *endogenously* slow adjustment of wages and NT prices => failure of ERBSs?
- the impact of euro conversion rate on nominal and real variables -- the size and persistence of misalignment, its effect on sectors and factors of production
- B-S effect with slow investment, *temporary* demand effect

Theoretical interpretation of NATREX

- long run: all state variables are stable
- medium run: all state variables that adjust fast are "temporarily unchanged" (e.g., H is along the dH/dt=0 location)
- realized behavior: all state variables adjust slowly
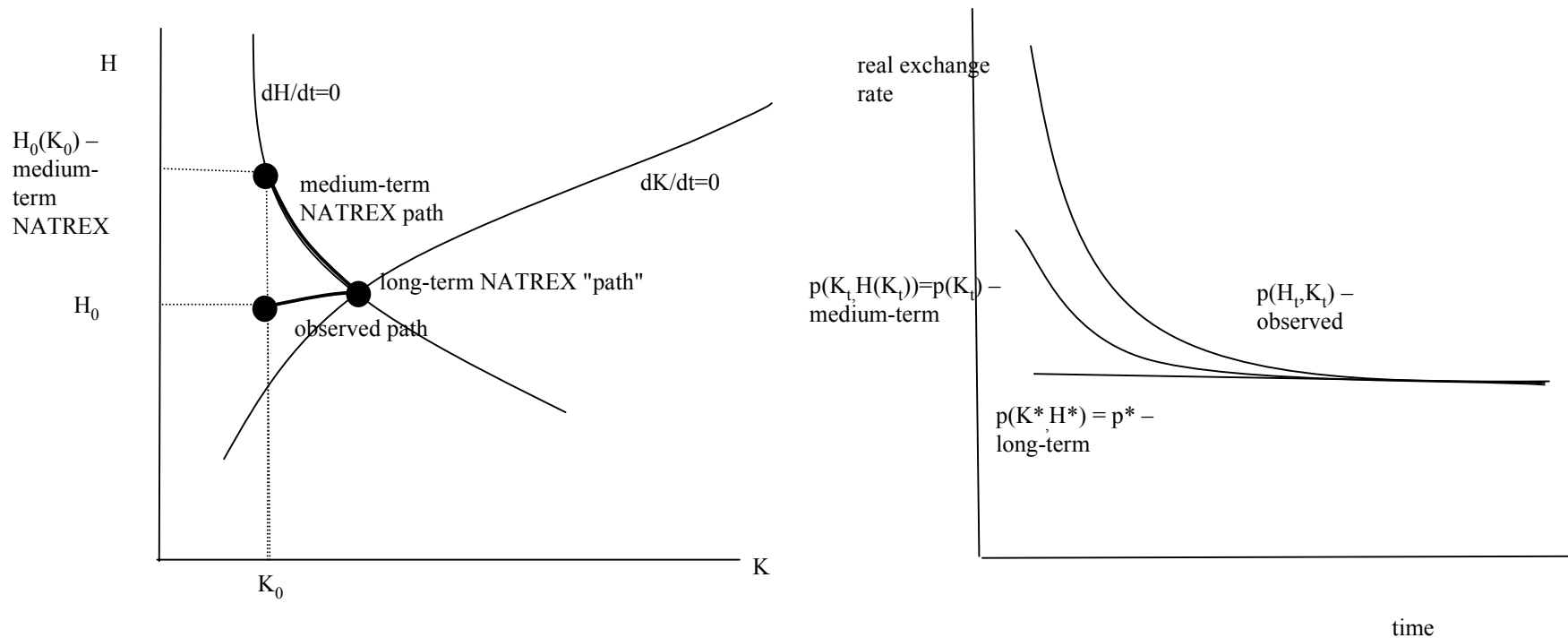
Model details

- 2 sectors: C-D prod., labor-augmenting exogenous growth in T (the long-run is then the "flexible Balassa-Samuelson model"); can transform all into effective variables

- 2 inputs: labor -- mobile across sectors, capital -- mobile across sectors but adjusts slowly between countries

- demand: intertemporal optimization of a C-D "aggregate" (T, NT consumption and real money -- H/P)

- a near-optimal policy function for nominal expenditure: $E=VH=(\delta+\pi)\gamma/(1-\gamma)H$ (neglects changes in π) -- have a continuous, full optimization version with qualitatively identical results (Benczur-Konya)

- consumer income: only w (K is foreign, capitalists eat only T)

- all markets clear except for

- *Tobin-q for capital ($r \neq r^*$), money accumulation ($E \neq Y$, $TB \neq 0$)*

Numerical solution (winsolve is enough!)

- dynamics:
$$\hat{\mathbf{K}}_{\mathbf{t}} = \hat{\mathbf{k}}_{\mathbf{T}} + \lambda \mathbf{V} \frac{\hat{\mathbf{H}}}{\mathbf{e}} * \hat{\mathbf{k}}_{\mathbf{T}}^{\beta} \left(\frac{1-\alpha}{1-\beta} - \frac{\alpha}{\beta} \right)$$

$$\mathbf{r} = (1-\beta)\mathbf{e}\hat{\mathbf{k}}_{\mathbf{T}}^{-\beta}$$

$$\hat{\mathbf{K}}_{\mathbf{t+1}} = \frac{\hat{\mathbf{K}}_{\mathbf{t+2}}}{2+\mathbf{r}*} + \frac{\hat{\mathbf{K}}_{\mathbf{t}}(1+\mathbf{r}*)}{2+\mathbf{r}*} + \frac{\mathbf{c}(\mathbf{r}/\mathbf{e}-\mathbf{r}*)}{2+\mathbf{r}*}$$

$$\hat{\mathbf{H}}_{\mathbf{t+1}} = \hat{\mathbf{H}}_{\mathbf{t}} + \frac{\mathbf{e}}{1+\mathbf{g}}\beta\mathbf{k}_{\mathbf{T}}^{1-\beta} - \frac{\mathbf{V}\hat{\mathbf{H}}_{\mathbf{t}}}{1+\mathbf{g}}.$$

- linearize laws of motion, can keep the per period equations
- calibration:
  - α=0.8, β= 0.5 (NT is more labor-intensive); λ=2/3 weight of NT
  - r*=0.005 (5% per year since 1 year = 10 periods), g=0.001 (1%)
  - c=3000 -- half-life of an innovation in K is appr. 2 years; V=0.1 -- half-life of a money shock is appr. 1 year
  - H_0, K_0 is 80-90-100% of steady state values

Intuition of model mechanics

- nominal appreciation (disinflation, strong EMU rate) increases the value of money in T

- this leads to excess spending, just like a fiscal stimulus

- higher consumption of NT and T, higher NT production, lower T production, trade deficit (H flows out)

- NT prices increase because the short-term transformation curve is nonlinear

- *propagation*: higher NT prices increase domestic income ("transfer effect")! Concretely: if NT is more labor-intensive, then wages increase

- the price of capital (r and q) falls, which hurts investment

- asymmetry: w↑, r↓; NT↑, T↓, reallocations between sectors

Results

- equilibrium growth paths, with different K_0: (1-2)

  $K<K^* \Rightarrow r>r^* \Rightarrow p_{NT}<p_{NT}^*$ (inverse Stolper-Samuelson) $\Rightarrow$ convergence means excess inflation (even w/o TFP growth) -- if the NT sector is more labor-intensive

- nominal growth paths: from equilibrium $H_0(K_0)$, e=1 and 0.9 (3-7) -- appr. 1% misalignment for around 2 years, but an important effect on r,w and K!

- the difference of the two nominal paths (i.e., the nominal impulse response of an appreciation): K, p, K_{NT}, K_T, L_T, L_{NT}, k_T ($\sim k_{NT}$), r/e, w/e, C, Y, TB, "real" GDP (8-16)

- sensitivity to the adjustment speed (c,V), initial values, fiscal expansion (dH>0 extra income)

Discussion, future research

- general intuition: the nominal exchange rate influences T prices, while some assets are fixed in local currency => change in demand => GE change in prices and income

- money, wealth or portfolio-rebalancing interpretations -- similar, but different impact and persistence

- role of approximations (E=VH, near-q theory): full optimization version in continuous time, the same intuition works ($\partial E_0/\partial H_0 > 0$, so an appreciation creates excess demand)

- the role of sectoral intensities, capital ownership?

- the role of unit substitutability
  - CES in consumption: high substitutability decreases the impact and the persistence, low subst. increases (*w* can even increase *more than 1:1*!)
  - CES in production: just the opposite (low subst. magnifies the effect)

Discussion, future research cont.

- slow reallocation between sectors:
  - sectoral q
  - Dixit-Stiglitz competition with temporary profits and gradual entry ("sticky entry") => endogenous T passthrough as well?
- the role of economic development (distance from steady state, the weight of rK)
- price or inflation inertia? success of ERBSs -- can we trace them to differences in the strenght of model effects?
- "sticky price" models: firms will not adjust to 100% exchange rate passthrough, so adjustment is even slower
- calibration on Hungarian data, or static/dynamics estimation? non-homotheticity of T-NT demand?