Exchange rate determination (Part II)

Readings

- Schmitt-Grohé et al. (2019) *International Macroeconomics*, Chapter 9 (excl. 9.3).

Learning objectives

- A theory of real exchange rate determination
  - Causality in the short-run using the Traded-Non-Traded model (with labour and technology rigidities)
  - Causality in the long-run using the Balassa-Samuelson model (free mobility of factors of production and productivity differentials)
- Explain the phenomenon of sudden stops using the TNT model

Contents:

Recap: nontradable goods and deviations from PPP

In the previous session we saw that there are large and persistent deviations from PPP. That is, the real exchange rate moves substantially over time.

This means that goods in a country become sometimes cheaper and other times more expensive. One reason for this observation is that not all goods are tradable.

$$P^T = \mathcal{E}P^{T*} \quad ; \quad P^N \neq \mathcal{E}P^{N*}; \tag{1}$$

$$P = \phi(P^T, P^N) \quad ; \quad P^* = \phi^*(P^{*T}, P^{N*}) \ , \tag{2}$$

where the function $\phi(.,.)$ is increasing in P^T & P^N and homogeneous of degree one (p. 296). Notably, the price of nontradables is determined entirely by domestic factors.

Therefore, the real exchange rate, e, can be written as:

$$e = \frac{\mathcal{E}P^*}{P} = \frac{\mathcal{E}\phi^*(P^{T*}, P^{N*})}{\phi(P^T, P^N)} = \frac{\phi^*(1, P^{N*}/P^{T*})}{\phi(1, P^N/P^T)} = \frac{\phi^*(1, p^*)}{\phi(1, p)} \tag{3}$$

where e depends on the relative price of nontradables in terms of tradables *across countries* (p^*, p).

In absolute terms, $e < 1$ implies that $p^* < p$ and the consumption basket is more expensive at home than abroad.

Recap, cont.

For small open economies, we often take foreign relative prices as given $(\bar{p}^*)$.

Therefore, when nontradables *become* more expensive relative to tradables, the domestic economy becomes more expensive relative to the rest of the world: e appreciates $\downarrow$.

Persistent failures (divergences) of PPP occurs when $e_t \neq 1$ for $t = 1, 2, 3, ...$. For example, e can appreciate (decrease) over time if:

(a) p_t increases relatively faster over time than abroad ($\bar{p}_t^*$); or,

(b) P_t^N rises faster than P_t^T, *ceteris paribus* . . .

For this reason, the relative price of nontradables in terms of tradables, p_t, is often referred to as the real exchange rate.

The TNT model

We now introduce two goods, one tradable and one nontradable, into our two-period open economy model studied in chapter 3.

Assumptions:

- Two-period endowment economy populated by many identical households, whose preferences are described by the utility function:

$$\ln C_1 + \beta \ln C_2 \ , \quad \beta \in (0,1) \tag{4}$$

- Tradable good (Q_t^T) can be imported or exported without restrictions;
- Nontradable good (Q_t^N) must be produced and consumed domestically.
- Consumption is a composite of both goods described by the Cobb-Douglas aggregation technology (see chapter 8.9):

$$C_t = (C_t^T)^{\gamma}(C_t^N)^{1-\gamma} \ , \quad t = 1,2 \text{ (period)}, \quad \gamma \in (0,1). \tag{5}$$

- Households can borrow or lend by means of a bond in period 1 (B_1), denominated in units of tradables and paying the interest rate r in period 2 (under free capital mobility)

The TNT model

We can write the period 1 and period 2 budget constraints as:

$$C_1^T + p_1 C_1^N + B_1 = Q_1^T + p_1 Q_1^N \quad (6)$$

$$C_2^T + p_2 C_2^N = Q_2^T + p_2 Q_2^N + (1+r) B_1 \ , \quad (7)$$

where $p_t \equiv \frac{P_t^N}{P_t^T}$.

Combining the two budget constraints to eliminate B_1 gives us the intertemporal budget constraint for households:

$$C_2^T = Y - p_2 C_2^N - (1+r)(C_1^T + p_1 C_1^N) \ , \quad (8)$$

where $Y \equiv Q_2^T + p_2 Q_2^N + (1+r)(Q_1^T + p_1 Q_1^N)$ denotes the household's lifetime income.

The TNT model

Finally, using the aggregator functions (5) to eliminate C_1 and C_2 from the utility function (4), and substituting out C_2^T using the budget constraint (8) (for convenience), the household's optimization problem reduces to choosing C_1^T, C_1^N, and C_2^N to maximize:

$$\begin{aligned} & \gamma \ln C_1^T + (1-\gamma)\ln C_1^N \\ + \quad & \beta\gamma \ln[Y - p_2 C_2^N - (1+r)(C_1^T + p_1 C_1^N)] + \beta(1-\gamma)\ln C_2^N . \end{aligned} \tag{9}$$

We obtain the first order conditions by taking the derivative of (9) with respect to the control/choice variables and equating them to zero. After some simplification (see p. 322) we get the following optimality conditions:

$$C_2^T = \beta(1+r)C_1^T \tag{10}$$

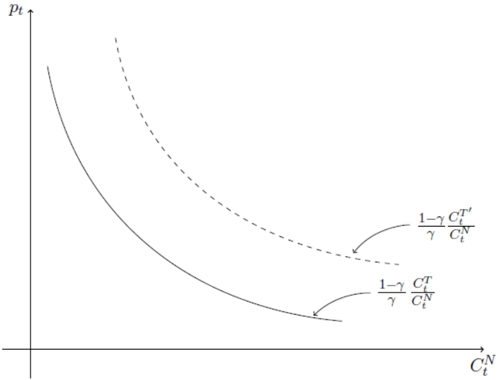
$$C_t^N = \frac{1-\gamma}{\gamma}\frac{C_t^T}{p_t}\ , \quad t = 1,2\ . \tag{11}$$

(10) is the Euler equation. (11) represents the demand for nontradables, given C_t^T.

We will now look at the demand schedule (11) in the space (C_t^N, p_t) ...

The TNT model: Demand schedule for nontradables

Figure 9.1: The Demand Function for Nontradables



Notes. The figure depicts the demand schedule for nontradables in period t. Holding consumption of tradables, C_t^T, constant, the higher is the relative price of nontradables, p_t, the lower the demand for nontradables, C_t^N, will be. An increase in the desired consumption of tradables from C_t^T to $C_t^{T'}$ shifts the demand schedule for nontradables out and to the right.

The TNT model: Equilibrium

In equilibrium, the market for nontradable goods must clear:

$$C_t^N = Q_t^N \ , \quad t = 1, 2.$$

Using this condition, we obtain the intertemporal *resource* constraint from (8):

$$C_2^T = Q_2^T + (1+r)(Q_1^T - C_1^T) \ . \tag{12}$$

What do you notice between this result and the one from Chapter 3? [Hint: $TB_1 = Q_1^T - C_1^T$, and we are assuming $B_0 = 0$.]

Combining (12) with the Euler equation (10) gives the equilibrium level of consumption of tradables in period 1:

$$C_1^T = \frac{1}{1+\beta}\left(Q_1^T + \frac{Q_2^T}{1+r}\right) \tag{13}$$

As in Ch. 3, the consumption of tradables depends on the present discounted value of the stream of tradable endowments. We summarize as:

$$C_1^T = C^T(\underbrace{\underset{-}{r}, \underset{+}{Q_1^T}, \underset{+}{Q_2^T}}_{\text{exogenous variables}}). \tag{14}$$

The TNT model: Equilibrium

The trade balance in period 1 follows as:

$$
\begin{aligned}
TB_1 &= Q_1^T - C_1^T = Q_1^T - \frac{1}{1+\beta}\left(Q_1^T + \frac{Q_2^T}{1+r}\right) \\
&= \frac{\beta}{1+\beta}Q_1^T - \frac{1}{1+\beta}\left(\frac{Q_2^T}{1+r}\right) \quad \text{[recall: } \beta \in (0,1)\text{]} \\
&= TB(\underset{+}{r}, \underset{+}{Q_1^T}, \underset{-}{Q_2^T}) \qquad (15)
\end{aligned}
$$

The current account in period 1 follows as:

$$
\begin{aligned}
CA_1 &= rB_0 + TB_1 = TB_1 \quad \text{[recall: } B_0 = 0\text{]} \\
&= CA(\underset{+}{r}, \underset{+}{Q_1^T}, \underset{-}{Q_2^T}) \,. \qquad (16)
\end{aligned}
$$

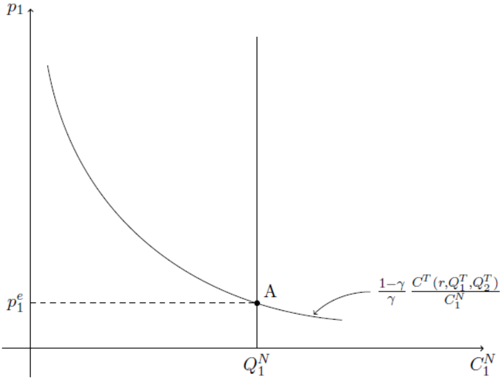
From (11) we obtain the following period 1 demand schedule for nontradables:

$$
C_1^N = \frac{1-\gamma}{\gamma}\frac{C^T(r, Q_1^T, Q_2^T)}{p_1} \,. \qquad (17)
$$

Given the fixed supply of nontradables (Q_1^N), we obtain the equilibrium value of the relative price of nontradables . . .

The TNT model: Equilibrium

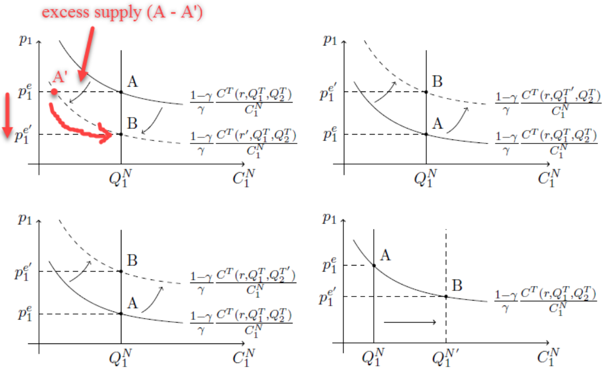
Figure 9.2: The Equilibrium Relative Price of Nontradables



Notes. The figure depicts the demand and supply functions of nontradables. The demand for nontradables is downward sloping and the supply schedule is a vertical line. The equilibrium relative price of nontradables is p_1^e, given by the intersection of the demand and supply schedules, point A.

The TNT model: Adjustment to interest-rate and endowment shocks

Figure 9.3: Effects of Interest-Rate and Endowment Shocks on the Relative Price of Nontradables



Notes. The figure depicts the effect on the relative price of nontradables, p_1, of changes in four exogenous variables. Top left panel: An increase in the interest rate from r to r' shifts the demand schedule down and to the left causing a fall in p_1. Top right and bottom left panels: An increase in the period-1 endowment from Q_1^T to $Q_1^{T\prime}$, or in the period-2 endowment from Q_2^T to $Q_2^{T\prime}$, shifts the demand schedule for nontradables out and to the right, driving p_1 up. Bottom right panel: An increase in the endowment of nontradables from Q_1^N to $Q_1^{N\prime}$, shifts the supply of nontradables to the right, resulting in a fall in the equilibrium value of p_1.

The TNT model: Summary

$$p_1 = p(\underset{-}{r}, \underset{+}{Q_1^T}, \underset{+}{Q_2^T}, \underset{-}{Q_1^N}) \tag{18}$$

- An increase in the world interest rate causes a fall in the equilibrium price of nontradables
- An increase in tradable endowment represents a positive income effect, which increases demand for consumption. The size of the increase in p_1^e depends whether the shock is temporary or permanent.
- An increase in the endowment of nontradables causes the relative price of nontradables to decline.

Holding the foreign relative price of nontradables constant (p_t^*), the real exchange rate is a *decreasing* function of p_t, and follows as:

$$\begin{aligned} e_1 &= \frac{\phi^*(1, p_t^*)}{\phi(1, p_t)} \\ &= e(\underset{+}{r}, \underset{-}{Q_1^T}, \underset{-}{Q_2^T}, \underset{+}{Q_1^N}, \underset{+}{p_1^*}) \end{aligned} \tag{19}$$

These results carry over to terms-of-trade shocks ($TT_t = P_t^X / P_t^M$):

$$e_1 = e(\underset{+}{r}, \underset{-}{TT_t} Q_1^T, \underset{-}{TT_t} Q_2^T, \underset{+}{Q_1^N}, \underset{+}{p_1^*}) \tag{20}$$

Sudden stops

A sudden stop occurs when foreign lenders abruptly stop extending credit to a country, which leads to a sharp increase in the interest rate.

Factors that trigger sudden stops include, e.g.:

- Inability to repay external debt obligations (↑ risk premium)
- Disruptions in international credit markets (↑ world interest rate)

$$r = r^* + RP$$

Three hallmark consequences of sudden stops are:[1]

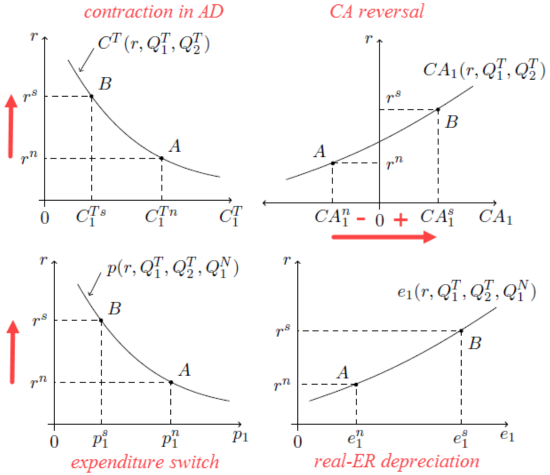
1. a *current account reversal*;
2. a contraction in aggregate demand; and
3. a real exchange rate depreciation.

The TNT model captures these three stylized facts, using (14), (16), (18), (19).

[1] Examples: Latin American debt crisis of the early 1990s; Mexican Tequila Crisis of 1994; Asian financial crisis of 1997; the Russian crisis of 1998; the Argintine crisis of 2001; debt crises in the periphery of Europe and Iceland after the GFC of 2007-2009.

A sudden stop through the lens of the TNT model

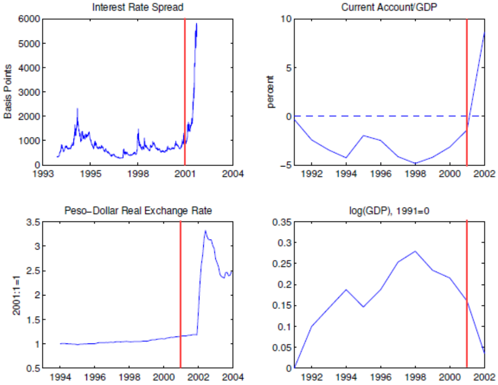
Figure 9.4: Effects of a Sudden Stop as Predicted by the TNT Model



Notes. A sudden stop is modeled as an increase in the world interest rate. In the figure, the interest rate increases from a normal level, denoted r^n, before the sudden stop, to a high level, denoted r^s, after the sudden stop. The sudden stop causes a contraction in the domestic absorption of tradables, a current account reversal, a fall in the relative price of nontradables, and a real-exchange-rate depreciation.

Case study: the Argentine Sudden Stop of 2001

Figure 9.5: The Argentine Sudden Stop of 2001



Notes. The figure displays the behavior of the interest rate spread of Argentine dollar-denominated bonds over U.S. treasuries, the current-account-to-GDP ratio, the real exchange rate, and real per capita GDP around the Argentine sudden stop of 2001. The sudden stop was characterized by a sharp increase in the country spread, a current account reversal, a real-exchange-rate depreciation, and a large contraction in GDP.

Case study: the Argentine Sudden Stop of 2001

What can explain the large real-exchange-rate depreciation?

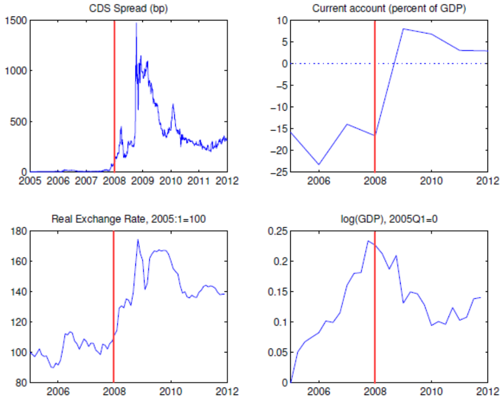
- S-GUW (2019) show that the sudden stop itself caused the real depreciation:

  With P^T fixed (LOOP), extremely weak domestic demand drives down the relative price of nontradables & therefore results in a real exchange rate depreciation.

- Balassa-Samuelson model implausible (next session): requires 400% TFP growth in tradables relative to non-tradables in U.S. over 2001-2002
- Tariff changes equally unlikely (check).

Case study: the Icelandic Sudden Stop of 2008

Figure 9.6: The Islandic Sudden Stop of 2008



Notes. The figure displays the behavior of the Islandic CDS spread, the current-account-to-GDP ratio, the real exchange rate against the euro, and real GDP around the sudden stop of 2008. The sudden stop was characterized by a sharp increase in the CDS spread, a large current account reversal, a real-exchange-rate depreciation, and a contraction in the level of real GDP.

Long-run movements of the real exchange rate

The Balassa-Samuelson model is appropriate to study *long-run* deviations from PPP because factors of production (labour, technology, capital) change slowly over time, and at different paces across sectors (tradable, nontradable).

The Balassa-Samuelson model predicts that persistent movements in the real exchange rate (or the relative price of nontradables) are due to *cross-country differentials in relative (labour) productivities in the traded and nontraded sectors*.

$$e = \frac{\phi^*(1, P^{N*}/P^{T*})}{\phi(1, P^N/P^T)} = \frac{\phi^*(1, a_T^*/a_N^*)}{\phi(1, a_T/a_N)}$$

- Can you think of a measure in the economy that represents the marginal product labour? (see pp. 373-5)

The Balassa-Samuelson Model

We assume full labour mobility between sectors ($L^T + L^N = \bar{L}$), such that the *nominal* wage rate must equate across sectors in equilibrium.

Given the linear production technologies in the traded and nontraded sectors,

$$Q^T = a_T L^T \text{ and } Q^N = a_N L^N ,$$

and the sectoral objective functions,

$$\max_{\{L^T\}} \text{Profits}^T = P^T Q^T - W L^T \text{ and } \max_{\{L^N\}} \text{Profits}^N = P^N Q^N - W L^N ,$$

we obtain the competitive equilibrium conditions for the labour market:

$$a_T = \frac{W}{P^T} \; ; \;\; a_N = \frac{W}{P^N} \; . \tag{21}$$

The equations in (21) state that labour productivity equals the real wage of each sector, respectively.[2]

[2] The linear production technology implies that $Q/L = \partial Q / \partial L = a$.

The Balassa-Samuelson Model

From (21), we see that for a given $\bar{W}$, a and P are inversely related: $1/a_T < 1/a_N \;\rightarrow\; P^T < P^N$.

Combining our optimality conditions in (21) to eliminate W (and repeating this model for a foreign economy) gives:

$$\frac{P^N}{P^T} = \frac{a_T}{a_N}\;;\quad \frac{P^{N*}}{P^{T*}} = \frac{a_T^*}{a_N^*}. \tag{22}$$

The equilibrium real exchange rate, from (3), is now given by

$$e = \frac{\phi^*(1, P^{N*}/P^{T*})}{\phi(1, P^N/P^T)} = \frac{\phi^*(1, a_T^*/a_N^*)}{\phi(1, a_T/a_N)} \tag{23}$$

(23) shows that e falls over time (appreciates) when the relative productivity of the traded sector in the domestic country grows faster than in the foreign country.[3]

[3] That is, the domestic country will become more expensive relative to the foreign country. Typically, we might see this in EMs as they “catch-up” to AEs.

Productivity differentials and the real exchange rate: the Balassa-Samuelson Model

- Productivity differentials across countries are most extreme in trade goods sector:

$$a_T/a_N > a_T^*/a_N^* \Rightarrow P_N/P_T > P_N^*/P_T^*$$

The B-S effect presents hypotheses about the structural origins of inflation:

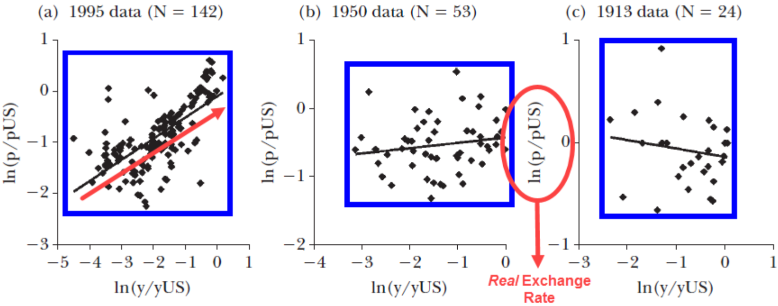
(1) International: the tendency for inflation in the catching-up economies to be higher than in the economies they are converging to;

(2) Domestic: the tendency for the domestic prices of non-tradables to *rise faster* than those of tradables.[4]

[4] Greater productivity in the traded goods ('modern') sector pushes wage levels up. Intersectoral labour mobility implies prices of nontraded goods must rise. Since the overall price index is a weighted average of traded and nontraded goods prices, relatively rich countries will tend to have appreciating real ex. rates (i.e.,"overvalued" currencies). (Taylor and Taylor, 2004, p. 151)

Balassa-Samuelson Effects Emerge

Figure: Log Price Level versus Log Per Capita Income



Notes: This figure shows countries' log price level (vertical axis) against log real income per capita for 1995, 1950 and 1913, with the United States used as the base country.

Real appreciation for country i:

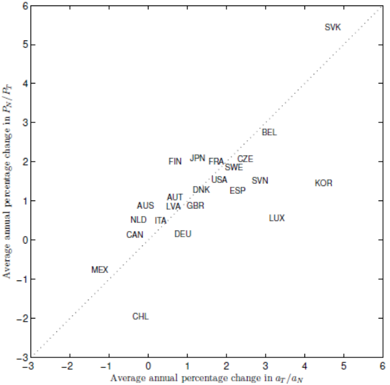
$$\uparrow e^{us/i} = \frac{S^{\$/i} P^i}{P^{us}} = \frac{P^{i,\$}}{P^{us}} \Rightarrow e^{us/i} = \frac{\phi(1, a_T^i / a_N^i)}{\phi(1, a_T^{us} / a_N^{us})}$$

Hypothesis: as per capita income rises, driven by productivity growth in tradables, then [dollar] price levels should also rise (Taylor and Taylor, 2004, 152).

Relative domestic productivity differentials: the B-S Model

(2) The domestic version: Does $\%\Delta \frac{P_N}{P_T}$ = $\%\Delta \frac{a_T}{a_N}$ in the data?

Figure 9.18: Relative Productivity Growth in the Traded and Nontraded Sectors and Changes in the Relative Price on Nontradables

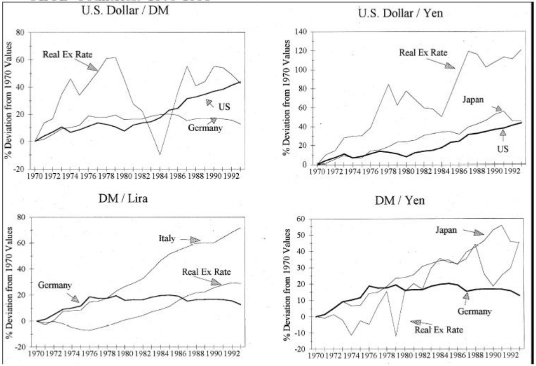


Notes. The figure plots the average annual percentage change in the relative price of nontradables in terms of tradables, P^N/P^T, against the average annual percentage change in productivity in the traded sector relative to the nontraded sector, a_T/a_N, for 23 countries over the period 1996 to 2015. The strong positive relationship provides empirical support to the Balassa-Samuelson model. Source: Own calculations based on data from KLEMS and OECD STAN.

Relative international productivity differentials: the B-S Model

(1) The international version: Does $\%\Delta e^{R/\$} = \nu^* \%\Delta \frac{a_T^{US}}{a_N^{US}} - \nu \%\Delta \frac{a_T^{RSA}}{a_N^{RSA}}$ appear in the data? (ν^* and ν are the weights on nontradables.)

Figure 9.5: The Real Exchange Rate and Labor Productivity in selected OECD Countries: 1970-1993



Source: Matthew B. Canzoneri, Robert E. Cumby, and Behzad Diba, "Relative Labor Productivity and the Real Exchange Rate in the Long Run: Evidence for a Panel of OECD Countries," *Journal of International Economics* 47, 1999, 245-266.

The structural factor that explains the tendency in both cases is the relative productivity growth differential:

- Historically: productivity growth in the traded goods sector has been faster than in the non-traded goods sector.
- If LOOP holds: the prices of tradables tend to get equalised across countries, while the prices of non-tradables do not.
- Higher a_T will bid up wages in that sector and, with labour being mobile, $w \uparrow$ in the entire economy.
- Producers of non-tradables will be able to pay the higher wages only if the relative price of non-tradables rises. This will in general lead to an increase in overall inflation in the economy.
- Relative productivity differentials across countries are weakly connected to measured real exchange rates.[5]

In South Africa, we can hypothesize that the persistent (trend) depreciation of the real exchange rate from 1985 is due to slower relative productivity growth in the tradable sector. But this does not imply the higher domestic inflation we observe compared to advanced economies. Labour market frictions (such as unions and skills shortages) could explain the disconnect.

[5] Productivity differentials $\rightarrow$ most extreme in trade goods sector: $a_T/a_N > a_T^*/a_N^*$

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