Nontradables, real exchange rate and pricing-to-market

Lecture 4, ECON 4330

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Motivation

The models developed so far have helped us start thinking about

- Current account dynamics as a response to *intertemporal* optimization
- The determinants of world interest rate in symmetric equilibrium
- ‘Sustainability’ of foreign debt using the intertemporal budget constraint
- Link between growth and savings/current account in an OLG framework

Motivation II

Today we will try to understand more of:

- What determines the relative price of nontradables and tradables
- How this is linked to the *real exchange rate*
- Whether differences in productivity can explain the decline of manufacturing employment observed in (many) Western countries
- A digression on pricing-to-market

Ambitious!

Outline

Definitions

Start by defining a few terms:

- Price level, P_t (P_t^* for 'abroad')
  - Real life: Usually an index or a GDP deflator
  - Model: Measure it in *units of tradable good*.
- Real exchange rate, Q_t.
  - Real life: Price of some basket of goods abroad relative to domestic price. Measured as EP^*/P, where E is the nominal exchange rate
  - Model: Both price indices are in units of tradables, hence $Q = P^*/P$ (or, equivalently, $E = 1$).

Definitions II

- Purchasing power parity (PPP)
  - Absolute PPP: The hypothesis that the price of any consumption basket should be the same in all countries ($Q_t = 1$ in the long run)
  - Relative PPP: A modified version requiering the *change* in relative prices to be the same in all countries ($Q_t =$ constant in the long run)
- Law of one price (LOI): All *goods* should have the same price in all countries
  - LOI implies PPP
  - PPP does not imply LOI
- Pass-through: Measures to what extent changes in exchange rates affects the prive level. Under PPP, the pass-through is one.

Outline

1. Preliminaries
2. Determination of (domestic) relative price of nontradables
3. Real exchange rate and productivity differences
4. Productivity trends and size of tradables sector
5. Pricing to market

Relative price of nontradables

So far our models have only involved one good. Let us introduce *nontradables*.

- A country produces Y_T tradables and Y_N nontradables
- Tradables can be imported and exported without any costs, while nontradables are impossible to export/import
- Capital is internationally mobile
- Labor is mobile across sectors, but not across countries
- Use the tradable good as numeraire. p is the relative price of nontradables. w is the wage rate. r is the world interest rate.

Under these assumptions, we'll see that the relative nontradables price is determined solely by the supply side.

Relative price of nontradables II

Output is assumed to be given by two production functions:

$$Y_T = A_T F(K_T, L_T) \tag{1}$$
$$Y_N = A_N G(K_N, L_N) \tag{2}$$

Assume constant returns to scale and define capital intensities $k_T = K_T/L_T$ and $k_N = K_N/L_N$, as well as $F(K/L, 1) = f(k)$ and $G(K/L, 1) = g(k)$. We can write:

$$F_1'(K, L) = F'(\frac{K}{L}, 1) = f'(k)$$
$$F_2'(K, L) = f(k) + f'(k)\frac{dk}{dL}L = f(k) - f'(k)k$$

and likewise for $g(k)$.

Relative price of nontradables III

Production takes place in representative firms that are price-taking profit maximizers. The firms demand capital and labor such that the following first-order conditions are satisfied:

$$A_T F_1'(K_T, L_T) = r \ \Rightarrow A_T f'(k_T) = r \tag{3}$$

$$A_T F_2'(K_T, L_T) = w \ \Rightarrow A_T [f(k_T) - f'(k_T) k_T] = w \tag{4}$$

$$pA_N F_1'(K_N, L_N) = r \ \Rightarrow pA_N f'(k_N) = r \tag{5}$$

$$pA_N F_2'(K_N, L_N) = w \ \Rightarrow pA_N [f(k_N) - f'(k_N) k_N] = w \tag{6}$$

Relative price of nontradables IV

The two first-order conditions for the tradable goods sector will pin down k_T and w:

- From (3), we first find the capital intensity that makes the return on capital equal to the world interest rate. Hence it defines $k_T(r, A_T)$.
- Then w follows from (4), since this defines the real wage implied by the marginal product of labor for a given capital intensity in the tradables sector. Defines $w(r, A_T)$.

Relative price of nontradables V

Then (5)-(6) can be used to solve for p and k_N. Let us look at this graphically. (5) implies

$$\frac{dp}{dk_N} = -p\frac{g''(k_N)}{g'(k_N)} > 0$$

Interpretation? From the choice of capital, a higher nontradables price is only consistent with a higher capital intensity since the return to capital must be equal to the world interest rate.

Relative price of nontradables V

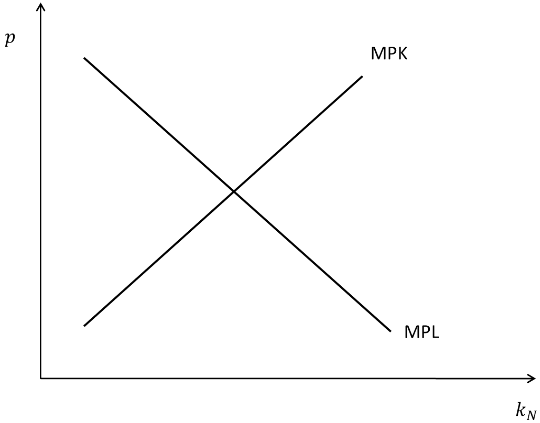
Implicit differentiation of (6) gives:

$$\frac{dp}{dk_N} = p\frac{g''(k_N)k_N}{g(k_N) - g'(k_N)k_N} < 0$$

Interpretation? From optimal labor demand, a higher real price is only consistent with a *lower* capital intensity since the return to labor must stay constant.

Relative price of nontradables VI

Draw the two conditions in a (k_N, p)-diagram:



Relative price of nontradables VII

To analyze how changes in exogenous factors affect p and k_N, we can either do it analytically or graphically.

- A change in A_T will shift the MPL-curve up since the real wage increases. Leads to a higher capital intensity k_N and higher price p
- A change in A_N will shift the MPK and MPL curves down (by the same proportion s.t. k_N is unchanged!) since this will keep pA_N unchanged. p falls.

Relative price of nontradables VIII

I prefer to derive analytically how the relative price is affected by the exogenous factors. To do so, recall that for a CRS production function,

$$F(K_t, L_t) = \frac{\partial F(K_t, L_t)}{\partial K_t} K_t + \frac{\partial F(K_t, L_t)}{\partial L_t} L_t$$

Using the first-order conditions we therefore have:

$$A_T f(k_T) = r k_T + w \tag{7}$$

$$p A_N g(k_N) = r k_N + w \tag{8}$$

Relative price of nontradables IX

Start by taking logs of (7) and then differentiate with respect to all variables:

$$\frac{dA_T}{A_T} + \frac{f'(k_T)dk_T}{f(k_T)} = \frac{k_T dr}{rk_T + w} + \frac{rdk_T}{rk_T + w} + \frac{dw}{rk_T + w}$$

Define $\hat{x} = dx/x$ as the percentage change and $\mu_T = w/A_T f(K_T)$ as the labor share in the tradables sector. With that we have:

$$\hat{A}_T + (1-\mu_T)\hat{k}_T = (1-\mu_T)\hat{r} + (1-\mu_T)\hat{k}_T + \mu_T \hat{w}$$

where I have also used $f'(k_T) = r$. Since the $\hat{k}_T$-terms cancel out, we are left with

$$\hat{A}_T = (1-\mu_T)\hat{r} + \mu_T \hat{w}$$

Relative price of nontradables X

Then we do the same exercise for (8). Taking logs and differentiating yields:

$$\frac{dp}{p} + \frac{dA_N}{A_N} + \frac{g'(k_N)dk_N}{g(k_N)} = \frac{k_N dr}{rk_N + w} + \frac{rdk_N}{rk_N + w} + \frac{dw}{rk_N + w}$$

If $\mu_T = w/pA_N g(K_T)$ is the labor share in nontradables we get:

$$\hat{p} + \hat{A}_N = (1 - \mu_N)\hat{r} + \mu_N \hat{w}$$

Relative price of nontradables X

Assume first $\hat{r} = 0$. Then

$$\hat{w} = \hat{A}_T / \mu_T$$

which shows that the real wage is increasing in A_T since the marginal product of labor in tradables goes up. This implies that

$$\hat{p} = \frac{\mu_N}{\mu_T} \hat{A}_T - \hat{A}_N$$

It seems reasonable to assume that $\mu_N \geq \mu_T$. **In that case faster productivity growth in tradables than nontradables should lead to a higher relative price of nontradables over time.** Why? This is because higher productivity in tradables lead to a higher real wage, thus 'forcing' nontradable-production to become more capital intensive, which is only possible at a higher relative price.

Relative price of nontradables XI

Next assume $\hat{A}_T = \hat{A}_N = 0$. Then

$$\hat{w} = -\frac{1-\mu_T}{\mu_T}\hat{r}$$

which shows that the real wage is decreasing in the world interest rate since the capital intensity goes down. This implies that

$$\hat{p} = \frac{1}{\mu_T}(\mu_T - \mu_N)\hat{r}$$

Keep on assuming that $\mu_N \geq \mu_T$. **In that case a larger world interest rate should reduce the relative price of nontradables.**

Relative price of nontradables: Application

So we have a clear prediction: As the tradables sector becomes relatively more productive than nontradables, the real price of nontradables should go up. Clearly larger scope for productivity gains in manufacturing than services. Expect to see this both across countries and over time.

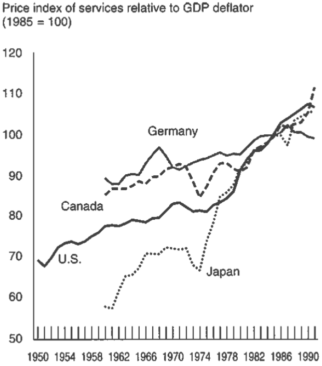


Figure 4.3
The relative price of services

Relative price of nontradables: Application II

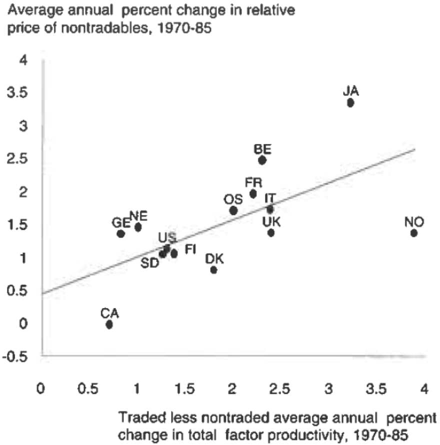


Figure 4.4
Differential productivity growth and the price of nontradables.

Relative price of nontradables: Application III

Would also expect richer countries to have a higher relative price of nontradables.

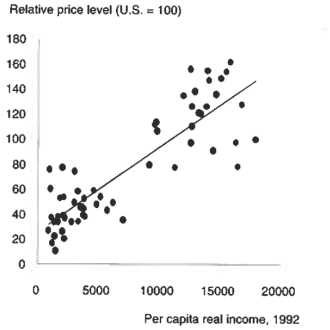


Figure 4.1
Real per capita incomes and price levels, 1992. (*Source:* Penn World Table)

Outline

Real exchange rate

Then we use what we have done so far to develop a simple model for RER determination. Let P (P^*) be the domestic (foreign) price level, measured in terms of *tradables*. Let us assume the price levels can be defined as

$$P = (1)^{\gamma} p^{1-\gamma}$$
$$P^* = (1)^{\gamma} (p^*)^{1-\gamma}$$

where γ is the (common) weight on tradables in the CPI of each country. The real exchange rate is therefore

$$Q = \frac{P^*}{P} = \left(\frac{p^*}{p}\right)^{1-\gamma}$$

Real exchange rate II

Take logs of the RER-definition and do total differentiation. We get:

$$\frac{dQ}{Q} = (1-\gamma)\left(\frac{dp^*}{p^*} - \frac{dp}{p}\right)$$

or, once we re-introduce hats and use our results for price-effects when $\hat{r} = 0$ (assuming the same labor share in sectors across countries):

$$\hat{Q} = (1-\gamma)\left(\frac{\mu_N}{\mu_T}\left[\hat{A}_T^* - \hat{A}_T\right] - \left[\hat{A}_N^* - \hat{A}_N\right]\right)$$

Home will experience a real appreciation ($\hat{Q} < 0$) if it has a larger relative improvement in its tradables sector compared to its nontradables sector.

Application: The HBS effect

The Harrod-Balassa-Samuelson effect is “a tendency for countries with higher productivity in tradables compared with nontradables to have higher price level.” In our model this is the same as expecting to see a real exchange appreciation in countries with the fastest productivity growth in tradables vs. nontradables.

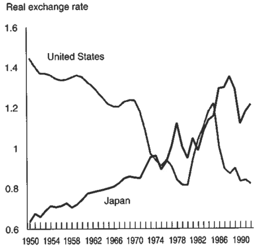


Figure 4.5
Real exchange rates for Japan and the United States, 1950–92. (*Source:* Penn World Table)

See figure (NOTE: RER IS THERE DEFINED AS $1/Q$, so a higher level implies real appreciation). O& R argue that compared to the US, Japan's A_T-growth was much higher, while its A_N-growth was lower. Figure is consistent with that story.

Outline

Productivity trends and sector size

- Observation I: Differences in productivity growth between sectors may explain why the relative price of nontradables has been increasing over time. Can be explained with our model.
- Observation II: Many Western countries have seen their manufacturing (tradable goods) sectors shrink in size the last four decades.
- Hypothesized explanation: Productivity is growing much faster in tradable than the nontradable sector. Hence a large share of the resources (labor) will over time be shifted from T to N
- Can we investigate this proposed explanation with our model apparatus?

To analyze this, not enough to just look at the supply side. Must also have a model for how demand for tradables and nontradables evolve, as well as general equilibrium effects. Strategy: (i) Find consumption of nontradables as a function of productivity. (ii) Find labor demand from the nontradable sector. Combine to see how productivity affects nontradable employment.

Productivity trends and sector size II

Consumption: We model private households as a representative agent. We assume that consumption each period is chosen to maximize utility given by[1]

$$\left[\gamma^{\frac{1}{\theta}} C_T^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_N^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

Maximizing utility subject to $C_T + pC_N = Z$ (for a given level of expenditure Z) yields:

$$\frac{\gamma C_N}{(1-\gamma) C_T} = p^{-\theta}$$

Combining the optimality condition with the budget constraint gives consumption demand as a function of expenditure

$$C_N = \frac{p^{-\theta}(1-\gamma)Z}{\gamma + (1-\gamma)p^{1-\theta}}$$

[1] See 4.4-4.5 or Chapter 10 for a formulation with a *continuum* of goods, which is the standard set-up in journal articles and e.g. monetary policy analysis.

Productivity trends and sector size III

Once again: Take logs and do total differentiation:

$$\hat{C}_N = -\theta \hat{p} + \hat{Z} - \frac{(1-\theta)(1-\gamma)p^{-\theta} dp}{\gamma + (1-\gamma)p^{1-\theta}}$$

Then assume that $p = 1$ initially. We then get

$$\hat{C}_N = \hat{Z} - [\gamma\theta + (1-\gamma)]\hat{p}$$

Evaluated *in a steady state* the expenditure level must equal

$$Z = wL + r(K + B)$$

If we only focus at variations in the wage rate (r is given in the world market),

$$\hat{Z} = \frac{wL}{wL + r(K+B)}\hat{w} = \psi_L \hat{w}$$

where ψ_L is the labor share of **GNP**. Consumption of nontradables is therefore

$$\hat{C}_N = \psi_L \hat{w} - [\gamma\theta + (1-\gamma)]\hat{p}$$

Productivity trends and sector size IV

Supply side: We have already derived (assuming $\hat{r} = 0$ and $\hat{A}_N = 0$):

$$\hat{w} = \hat{A}_T / \mu_T$$

and

$$\hat{p} = \frac{\mu_N}{\mu_T} \hat{A}_T$$

where μ_T and μ_N are the labor shares in tradables and nontradables production, respectively. But to find this, we only cared about how capital intensities were determined (together with p and w). What about labor demand from the nontradable sector?

Productivity trends and sector size V

To get that, we impose some more structure. Assume that $G(K_N, L_N)$ is Cobb-Douglas with $\mu_N = 1 - \alpha$ being the (now constant) labor share.

$$Y_N = f(k_N)L_N$$

where $f(k_N) = k_N^{\alpha}$. We can therefore write

$$\hat{L}_N = \hat{Y}_N - \alpha\hat{k}_N$$

Then recall the optimality condition (5): $pA_N g'(k_N) = r$. Log-differentiation implies that

$$\hat{p} - (1 - \alpha)\hat{k}_N = 0$$

Therefore:

$$\hat{L}_N = \hat{Y}_N - \frac{\alpha}{1 - \alpha}\hat{p}$$

or

$$\hat{L}_N = \hat{Y}_N - \frac{\alpha}{\mu_T}\hat{A}_T$$

Productivity trends and sector size VI

Market clearing: Then we impose $C_N = Y_N$. What do we get? We know that labor demand is

$$\hat{L}_N = \hat{C}_N - \frac{\alpha}{\mu_T}\hat{A}_T$$

while consumption demand is

$$\hat{C}_N = \psi_L \hat{w} - [\gamma\theta + (1-\gamma)]\hat{p}$$

or, after inserting for $\hat{w}$ and $\hat{p}$:

$$\hat{C}_N = (\psi_L - (1-\alpha)[\gamma\theta + (1-\gamma)])\,\frac{\hat{A}_T}{\mu_T}$$

Inserting for $\hat{C}_N$ in labor demand we get the final expression.

Productivity trends and sector size VII

Employment in the nontradable sector is:

$$\hat{L}_N = (\psi_L - (1-\alpha)[\gamma\theta + (1-\gamma)] - \alpha)\,\frac{\hat{A}_T}{\mu_T}$$

Is it obvious that $\hat{A}_T > 0$ leads to $\hat{L}_N > 0$?

- The first term (Ψ_L) captures the fact that higher productivity (=more income) leads to more demand for nontradables, requirering higher employment in this sector
- But there are also two terms that lead to *lower* employment in the nontradable sector. First, higher productivity growth in tradables increase the relative price of nontradables, reducing the demand. Second, capital intensity of nontradables production is also rising in the relative price, which also reduces labor demand.

Conclusion: Not a necessity that an even more productive tradable goods sector must lead to larger nontradable employment.

Productivity trends and sector size: Application

A quick look at the data also indicates that the there's not a uniform tendency for employment in tradables to shrink.

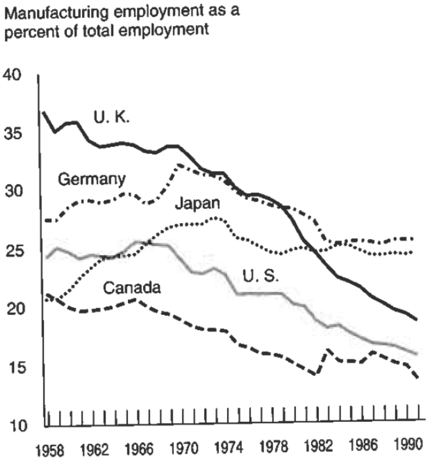


Figure 4.7
Employment in manufacturing

Outline

Pass-through

A topic that has received a lot of attention is *how strongly changes in the nominal exchange rate affects domestic prices*. Extremely important for monetary analysis.

- Under PPP, the import price of goods is EP^*. We have *complete pass-through*
- In practice: Low pass-through. There are especially two reasons for incomplete pass-through that have been studied.
  - 'Pricing-to-market': Models where exporting firms are reluctant to pass on exchange rate changes since they might loose market shares.
  - 'Producer vs. consumer currency pricing': This literature (e.g. Deveraux and Engel, 2002, Journal of Monetary Economics) but focus more at the effect how nominal rigidities matter for exchange rate volatility under PCP/LCP.

Pricing-to-market

Let us look at the question in a very simple model, building on Krugman (1987). Consider a market served by one domestic and one foreign supplier. Total demand:

$$Y = Y_H + Y_F = P^{-1/\varepsilon}$$

where $\varepsilon > 1$. There's market segmentation: Consumers cannot import themselves. The two suppliers engage in Cournot competition.

Pricing-to-market II

Home supplier's problem:

$$\max_{Y_H} \quad (Y_H + Y_F)^{-1/\varepsilon}\, Y_H - cY_H$$

conditional on Y_H, where c is the firm's fixed marginal cost. First-order condition:

$$(P - c) - \frac{1}{\varepsilon} P \frac{Y_H}{Y_H + Y_F} = 0$$

Let $s = Y_H/(Y_H + Y_F)$ denote the home firm's market share. The optimal pricing condition is then

$$P_H = \frac{\varepsilon}{\varepsilon - s} c$$

$\Rightarrow$ The mark-up depends on market share! For $s = 1$ we get the ordinary monopoly condition.

Pricing-to-market III

Foreign supplier faces an almost identical problem, except that its marginal cost is denoted in foreign terms:

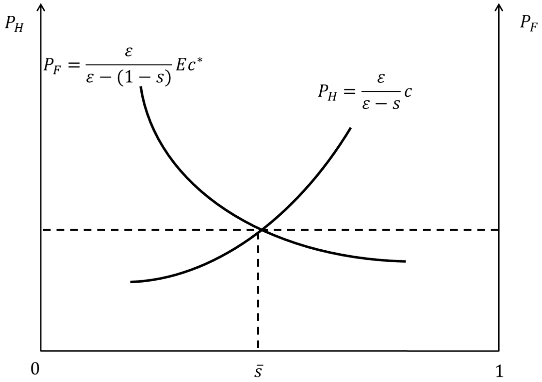
$$\max_{Y_F} \quad (Y_H + Y_F)^{-1/\varepsilon}\, Y_F - Ec^* Y_F$$

The optimal pricing formula is then

$$P_F = \frac{\varepsilon}{\varepsilon - (1 - s)} Ec^*$$

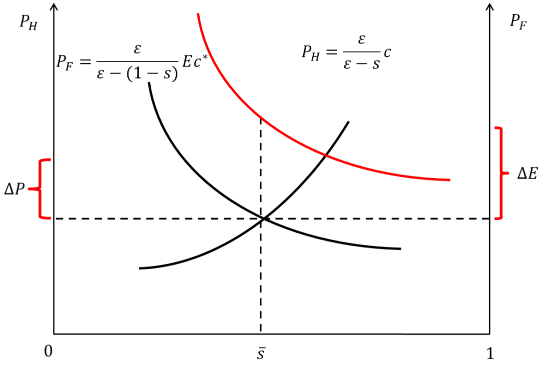
Pricing-to-market IV

We solve for equilibrium by finding the market share that makes the firms choose the same price ($P_H = P_F$):



Pricing-to-market V

Key question: What happens to the domestic price if the exchange rate depreciates ($\Delta E > 0$)? The domestic price will increase, but (potentially far) less than one-for-one!



Pricing-to-market: Application

A paper that demonstrates the relevance of pricing-to-market is Atkeson and Burstein (2008, American Economic Review). They show how PTM is sufficient to replicate an observed deviation from PPP (which many otherwise would have thought that sticky prices was necessary to replicate).

Pricing-to-market: Application II

Let us look at their empirical observations first. Define

- Terms of trade: Ratio of manufactured export and import price indices
- PPI-RER: Ratio of US producer price index for manufacture goods and a trade-weighted averaged of manufactured goods producer price indices for main trading partners (measured in US dollars)
- CPI-RER: Ratio of US consumer price index and a trade-weighted average of consumer prices for main trading partners (measured in US dollars)

Pricing-to-market: Application III

Consider a large movement in PPI-RER.

- Question: How should this affect export and import prices?
- Standard answer: Relative PPP should hold. Hence export and import prices should reflect producer prices. TOT should therefore be as volatile as PPI-RER.
- Question: How should this affect CPI-based RER?
- Standard answer: Relative PPP should hold. Changes in CPI should reflect a trade-weighted average ov changes in producer prices. Since some goods are nontradable, CPI-RER should be *smoother* than PPI-RER.

Pricing-to-market: Application IV

Does not look like this in the data:

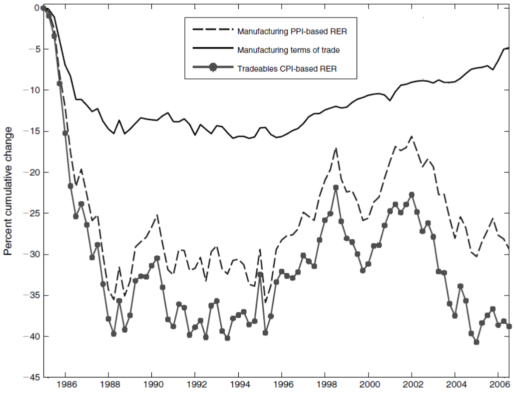


Figure 1. US Terms of Trade and Trade-Weighted Real Exchange Rates

Pricing-to-market: Application V

- Fact 1: TOT is much less volatile than PPI-RER
- Fact 2: CPI-RER is almost as volatile as PPI-RER

Atkeson and Burstein show how a fancy version of the Krugman-model we looked at can replicate these two facts. Why? consider an increase in productivity in one country.

- The reduction in marginal cost will *not* be fully passed on to export prices since their market share goes up, allowing them to increase their mark-up.
- This makes TOT less volatile than PPI-RER
- In addition, we need domestic consumer prices to be more sensitive to costs than foreign prices (to make CPI-RER as volatile as PPI-RER). They get that as long as exporting firms have a smaller market share abroad than at home (the relative change in mark-up is larger in export markets).