Summary Ch 8 Non-Tradable Goods and the Real Exchange Rate

The MX model overestimates the role of the TOT as a driver of fluctuations. Here we break the assumption that all goods are perfectly traded by introducing Non Tradable goods.

A first consequence is that we start accounting for the Real Exchange Rate. In too simplified models this variable is constant. Here it will fluctuate.

Real Exchange Rate: $$RER_t = \frac{\mathcal{E}_t P_t^*}{P_t} \qquad (1)$$

(Relative price of consumption goods baskets)

$\mathcal{E}_t$: Nominal ER. Price of foreign currency in terms of local currency units.

When RER **increases** the local goods basket becomes relatively expensive. This is denoted as an **depreciation.** Similarly, if the RER **decreases**, we observe an **appreciation**.

Three approaches: **1. TNT** model: endowment framework, **2. SVAR**: Empirical framework, **3. MXN**: SOE-RBC framework with exportable, importable and non-tradable goods.

TNT Model

Endowment Open Economy model, with one fully imported good (not domestically produced), one fully exported good (not domestically consumed), and one non-tradable good.

Households:

$$\max_{c_t^m c_t^n d_{t+1}} \sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t.

$$c_t = A(c_t^m, c_t^n),$$

$$c_t^m + p_t^n c_t^n + d_t = \frac{d_{t+1}}{1+r} + \underline{tot_t} y^x + p_t^n y^n$$

$$\lim_{j\to\infty} (1+r)^{-j} d_{t+j} \leq 0,$$

Units: importables ($P_t^m = 1$)

y^x, y^n: Constant endowments (n: Non tradable)

$A(\cdot,\cdot)$: Increasing, concave, HD1

d_t: External debt maturing in t

$r > 0$ interest rate (constant)

FOCs:

$[c_t^m]$: $$U'(c_t)A_1(c_t^m, c_t^n) = \lambda_t, \qquad (2)$$

$[d_{t+1}]$: $$\lambda_t = \beta(1+r)\lambda_{t+1}, \qquad (3)$$

$[c_t^n]'$: $$p_t^n = \frac{A_2(c_t^m, c_t^n)}{A_1(c_t^m, c_t^n)}, \qquad (4)$$

This condition involves $A_1(c_t^m, c_t^n)$ because $\lambda_t / U'(c_t)$ is replaced from (1) in the original FOC wrt c_t^n

$[TVC]$: $$\lim_{j\to\infty} (1+r)^{-j} d_{t+j} = 0. \qquad (5)$$

Given $A(\cdot,\cdot)$ is HD1, (4) can be rewritten as:

$[c_t^n]''$: $$p_t^n = P\left(\frac{c_t^m}{c_t^n}\right); \quad \text{with } P'(\cdot) > 0. \qquad (6)$$

Intuition: Consumption of NT (importables) decreases (increases) w/ price of NT goods

Link between RER and relative price of Non-Tradables: there is a one-to-one inverse relationship between the RER and the relative price of non-tradable goods.

This is why paper talk about RER and prices of Non-Tradables as analogous quantities

$$RER = \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\mathcal{E}_t P_t^* / P_t^m}{P_t / P_t^m} = \frac{P_t^* / P_t^{m*}}{P_t / P_t^m} = \frac{\cancel{P_t^{c*}}}{P_t^c}$$

1: Assumed exogenous, constant (and normalized)

Where the second to last equality uses the LOP assumption ($P_t^m = \mathcal{E}_t P_t^{m*}$)

This result implies the RER can be directly associated to the relative price of consumption goods (P_t^c).

Now we check how P_t^c is linked to P_t^n (and then how RER is linked to P_t^n)

Firms bundling (or producing) C_t by aggregating the sub-baskets C_t^m, C_t^n solve:

$$\max_{C_t^m, C_t^n} P_t^c A(C_t^m, C_t^n) - C_t^m - p_t^n C_t^n$$

FOCs:

$[C_t^m]$: $$P_t^c A_1(C_t^m, C_t^n) = 1$$

$$\Rightarrow A_1(C_t^m, C_t^n) = RER_t$$

given $A_1(\cdot,\cdot)$ is HD0: $A_1(C_t^m, C_t^n) = A_1\left(\frac{C_t^m}{C_t^n}, 1\right)$

and by (6): $= A_1(P^{-1}(P_t^n), 1) = RER_t$

then: $$RER_t = e(p_t^n) \quad , \quad \text{with } e'(\cdot) < 0 \qquad \left(\text{or } RER_t \propto \frac{1}{P_t^n}\right)$$

Therefore, if the prices of non-tradable **increase**, the RER **appreciates (decreases)**

Market clearing

Non-tradable goods: $$c^n = y^n \qquad (8)$$

can only be consumed/produced domestically

Subst. (8) in the HH budget constraint to obtain dynamics of debt (current account):

Resource constraint of tradable sector:

$$c_t^m + d_t = \frac{d_{t+1}}{1+r} + tot_t y^x. \qquad (9)$$

Intertemporal Budget Constaint analysis:

Now assume $\beta = \frac{1}{1+r}$

Then given (3) we have: $\lambda_t = \lambda \ \forall t \Rightarrow C_t^m = C^m$ (this follows because r is constant so it cancels out w/ β & because C^n is constant)

Iterate BC forward (to infinity) & use TVC (5): $$c^m = -\frac{r}{1+r} d_0 + \frac{r}{1+r} \sum_{t=0}^{\infty} \frac{tot_t y^x}{(1+r)^t}. \qquad (10)$$

The assumption ($\beta(1+r) = 1$) and the FOC wrt C_t^n Also imply: $C_t^n = C^n$

Then, by (6) we get an expression for the equilibrium RER: $$p^n = P\left(\frac{c^m}{y^n}\right) \qquad (11)$$

$\uparrow p^n \equiv \downarrow RER$ (RER appreciates)

RER appreciates when:

- Supply of non-tradable falls $y_t^n \downarrow$
- Current TOT or supply of tradables increase ($c^m \uparrow, tot_t \uparrow, y^x \uparrow$)
- Future TOT or y^x are expected to grow

Effects of TOT shocks

Temporary shock: tot_0 increases, other tot_t remain unchanged

Effect on RER: $$\left.\frac{\partial p^n}{\partial tot}\right|_{\text{temporary}} = \frac{r}{1+r} \frac{y^x}{y^n} P' \left(\frac{c^m}{y^n}\right) > 0.$$ RER decreases (appreciates)

Increase in relative price of exportables creates an income effect, driving up the demand for all goods. Given the supply of NT is fixed, its price increases to eliminate excess demand.

With higher price NT goods the RER will go down (appreciates).

Permanent shock: TOTt increases for all t (starting at t=0)

Effect on RER:

From (10) and (11) we have: $\left.\frac{\partial p^n}{\partial tot}\right|_{\text{permanent}} = \frac{y^x}{y^n}P'\left(\frac{c^m}{y^n}\right) > 0$

Moreoever, $\left.\frac{\partial p^n}{\partial tot}\right|_{\text{permanent}} > \left.\frac{\partial p^n}{\partial tot}\right|_{\text{temporary}} > 0$

the more permanent the increase in TOT the larger the income effect it generates, the larger will be the increase in NT demand, prices, RER appreciation

Effect on output:

Unexpected and permanent in crease in TOT at t=0

with non-tradable the output Yt is: $y_t = \frac{P_t^x y^x + P_t^n y^n}{P_t}$

Multiply/divide by P_t^m: $y_t = \frac{tot_t y^x + p_t^n y^n}{p_t^c}$

Given $p_t^c = \frac{1}{A_1(c^m,y^n)}$, $p_t^n = \frac{A_2(c^m,y^n)}{A_1(c^m,y^n)}$: $y_t = A_1(c_t^m,y^n)\, tot_t y^x + A_2(c_t^m,y^n)\, y^n$ (12)

Assume A(.,.) is a Cobb-Douglas aggregator: $A(c^m,y^n) = (c^m)^\alpha (y^n)^{1-\alpha}$

Then (12) becomes: $y_t = c_t\left[\alpha \frac{tot_t y^x}{c_t^m} + (1-\alpha)\right]$

Implying: $\left.\frac{\partial y_0}{\partial tot}\right|_{1-\alpha=0} = y^x > 0$ and $\left.\frac{\partial y_0}{\partial tot}\right|_{1-\alpha=1} = 0$

the larger the share of non-tradables in consumption the lower the effect of TOT shocks on output

We can see how the inclusion of NT goods dampens the effect of the TOT on the output. Then, adding NT goods can be good for reconciling the results in the model with the data. We do this in the MX-**N** model.

Interest Rate shocks:

One time increase in interest rate at t = 0: FOCs evaluated at imply that: $c_1^m > c_0^m$

In addition it follows that c_0^m falls wrt previous levels. Then: $\frac{\partial c_0}{\partial r_0} < 0$

This result, together with (6), (8) implies:

$$\frac{\partial p_0^n}{\partial r_0} = P'\left(\frac{c_0^m}{y^n}\right)\frac{1}{y^n}\frac{\partial c_0^m}{\partial r_0} < 0$$

RER depreciates (increases)

Intuition: Households want to save by consuming less of all goods. Given the supply of NT is fixed the price of non-tradables falls to clear the market

SVAR Empirical Evidence

Here the SVAR from the previous chapter is extended to include the RER.

Let: $x_t = \left[\, \widehat{tot}_t, \ \widehat{tb}_t, \ \hat{y}_t, \ \hat{c}_t, \ \hat{i}_t, \ \widehat{RER}_t \,\right]'$

SVAR: $x_t = h_x x_{t-1} + u_t$ **Identification of TOT shocks:** $u_t = \Pi\epsilon_t$, $\epsilon_t \sim (0, I)$, $\Pi_{1,j} = 0$ for $j = 2, \ldots, 6$

It is assumed the TOT is an exogenous univariate AR(1) process: $h_{x,1,j} = 0$ for $j = 2, \ldots, 6$

All variables except the TB are log-deviations from a quadratic trend.
For TB: trade balance divided by trend component of output and then removing a quadratic time trend

RER set relative to the US: $RER_t = \frac{\mathcal{E}_t P_t^{us}}{P_t}$

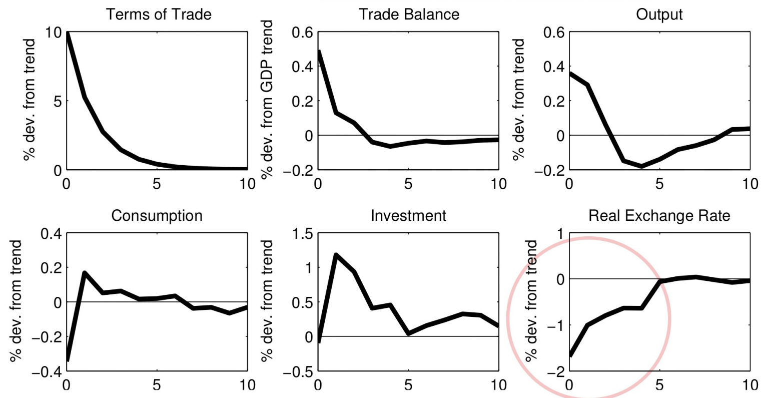
Data source: WDI (38 countries -w/ at least 30 consecutive data points in all variables-, poor and EMEs, period: 1980-2011, country-wise estimation)

$\widehat{tot}_t = \rho\widehat{tot}_{t-1} + \sigma_{tot}\epsilon_t^{tot}$; $\epsilon_t^{tot} \sim (0,1)$

Estimate ρ and σ_{tot} country by country

	ρ	$\frac{\sigma_{tot}}{\sqrt{1-\rho^2}}$
Median	0.52	0.10
Interquartile Range	[0.41, 0.61]	[0.09, 0.13]

Impulse Response to A 10% Increase in the Terms of Trade
SVAR Evidence, Median across 38 countries



- TOT shocks are short lived
- TB improves after the shock (HLM effect)
- TOT improvements are expansionary
- TOT increase leads to appreciation of RER (↓RER)

Variance decomposition:

	tot	tb	y	c	i	RER
Median	100	12	$\boxed{10}$	9	10	14
Median Absolute Deviation	0	7	7	6	7	11

TOT shocks explain on avg 10% of output.

Then this SVAR is also at odds w/ conventional wisdom (and MX model) indicating TOT is a key driver of fluctuations

MXN model

RBC-SOE extended to include exportable, importable and **non-tradable** goods.

-TOT are taken as given.
-All goods are produced and consumed (unlike TNT model) and production uses labor and K as input.
-Factors are specific to each sector.

The Household Problem: Maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t^m, h_t^x, h_t^n)$$

subject to the period budget constraint

$$c_t + i_t^m + i_t^x + i_t^n + p_t^\tau d_t + \Phi_m(k_{t+1}^m - k_t^m) + \Phi_x(k_{t+1}^x - k_t^x) + \Phi_n(k_{t+1}^n - k_t^n) = \frac{p_t^\tau d_{t+1}}{1+r_t} + w_t^m h_t^m + w_t^x h_t^x + w_t^n h_t^n + u_t^m k_t^m + u_t^x k_t^x + u_t^n k_t^n,$$

Units: Final Goods
p_t^τ: Relative price of tradables
d_t: Debt due in t

and to the laws of motion for physical capital

$$k_{t+1}^m = (1-\delta)k_t^m + i_t^m; \quad k_{t+1}^x = (1-\delta)k_t^x + i_t^x; \quad k_{t+1}^n = (1-\delta)k_t^n + i_t^n.$$

Final goods Firms: $\max \ a_t - p_t^\tau a_t^\tau - p_t^n a_t^n$

s.t. $a_t = \left[\chi_\tau (a_t^\tau)^{1-\frac{1}{\mu_{\tau n}}} + (1-\chi_\tau)(a_t^n)^{1-\frac{1}{\mu_{\tau n}}}\right]^{\frac{1}{1-\frac{1}{\mu_{\tau n}}}}$

a_t = domestic absorption of final goods a.
a_t^τ = domestic absorption of a composite of traded goods.
a_t^n = (domestic) absorption of nontraded goods.
$\mu_{\tau n}$ = elasticity of substitution between T and N goods.
χ_τ = expenditure share on tradables if $\mu_{\tau n}$.

Tradable good is a composite of imported and exported goods

Tradable composite good firms: $\max\{p_t^T a_t^T - p_t^m a_t^m - p_t^x a_t^x\}$

$$a_t^T = \left[\chi_m \left(a_t^m\right)^{1-\frac{1}{\mu_{mx}}} + (1-\chi_m)\left(a_t^x\right)^{1-\frac{1}{\mu_{mx}}}\right]^{\frac{1}{1-\frac{1}{\mu_{mx}}}}$$

$a_t^T =$ domestic absorption of tradable goods.
$a_t^m =$ domestic absorption of importable goods.
$a_t^x =$ domestic absorption exportable goods.
$\mu_{mx} =$ elasticity of substitution between importables and exportables.
$\chi_m =$ expenditure share if $\mu_{mx} = 1$.

Importable good firms:

$$\max_{h_t^m, k_t^m} \; p_t^m y_t^m - w_t^m h_t^m - u_t^m k_t^m$$
$$\text{s.t.} \quad y_t^m = A_t^m (k_t^m)^{\alpha_m} (h_t^m)^{1-\alpha_m}$$

Exportable good firms:

$$\max_{h_t^x, k_t^x} \; p_t^x y_t^x - w_t^x h_t^x - u_t^x k_t^x$$
$$\text{s.t.} \quad y_t^x = A_t^x (k_t)^{\alpha_x} (h_t)^{1-\alpha_x}$$

Non-tradable goods firms:

$$\max_{h_t^n, k_t^n} \; p_t^n y_t^n - w_t^n h_t^n - u_t^n k_t^n$$
$$\text{s.t.} \quad y_t^n = A_t^n (k_t^n)^{\alpha_n} (h_t^n)^{1-\alpha_n}$$

Interest rate (IDEIR):

$$r_t = r^* + p(d_{t+1})$$
$$p(d) = \psi\left(e^{d-\bar{d}} - 1\right)$$

TOT process:

$$\ln\left(\frac{tot_t}{\overline{tot}}\right) = \rho \ln\left(\frac{tot_{t-1}}{\overline{tot}}\right) + \sigma_{tot}\epsilon_t^{tot}; \quad \epsilon_t^{tot} \sim (0,1)$$

Calibrated parameters:

Calibrated Structural Parameters												
ρ	σ_{tot}	α_m, α_x	α_n	$\omega_m, \omega_x, \omega_n$	μ_{mx}	$\mu_{\tau n}$	$\overline{tot}$	A^m, A^n	β	σ	δ	r^*
*	*	0.35	0.25	1.455	1	0.5	1	1	$1/(1+r^*)$	2	0.1	0.11
Moment Restrictions												
$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_{tb}}{\sigma_y}$	$\frac{\sigma_{i_m+i_x}}{\sigma_{i_n}}$	s_n	s_x	s_{tb}	$\frac{p^m y^m}{p^x y^x}$						
*	*	1.5	0.5	0.2	0.01	1						
Implied Structural Parameter Values												
ϕ_m	ϕ_x	ϕ_n	ψ	χ_m	χ_τ	$\bar{d}$	A^x	β				
*	*	*	*	0.8980	0.4360	0.0078	1	0.9009				

* country specific estimates

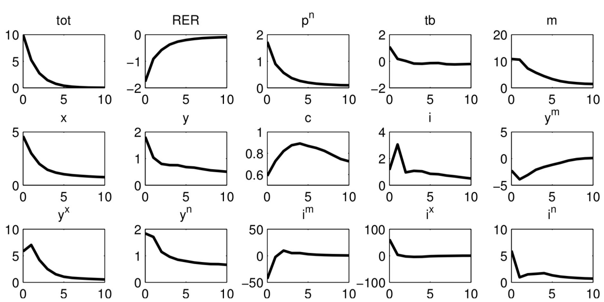
$\frac{\sigma_i}{\sigma_y}, \frac{\sigma_{tb}}{\sigma_y}$: Conditional on TOT shocks

$s_n : p^n y^n / y$, $s_x : x/y$, $s_{tb} : (x-m)/y$
with: $y = p^m y^m + p^x y^x + p^n y^n$

Relevant parameters for checking the effect of the TOT shocks:

- ρ and σ_{tot} : persistence and volatility of TOT shocks.
- Size of non-traded sector: $p^n y^n / y$ = 0.5. The larger the smaller the effect of TOT on output.
- Steady State trade share: (x+m)/y = 0.39. The larger, the larger the effect of TOT on output.

Median of country specific IRF to a ten percent TOT shock (MXN model)



- Supply side: Production of Exportables increases, of Importables decreases, of non-tradable goods increases.

- Demand side: Demand for importable goods and non-traded goods increases given lower relative price. Domestic demand for exportable goods falls. The improvement in TOT generates a wealth effect that increases total demand.

- Price of non-tradable rises (**RER appreciates**)

- Exports and imports increase. The **trade balance improves. Then the HLM effect holds.**

Comparison of data and theoretical counterparts

For comparison purposes we should measure the empirical and theoretical variables of the model in the same units. Then, a theoretical counterpart to the observable variables is constructed.

Unit: constant LCU (local currency units).
For the construction: deflate nominal variables by a Paasche GDP deflator

Share of Variance Explained by Terms of Trade Shocks: SVAR Versus MXN Predictions

	tb	y	c	i	RER
MXN Model	21	13	18	11	1
SVAR Model	12	10	9	10	14

Note. Cross-country medians.

- Median share of output explained by TOT shocks is similar to that of the SVAR.

- Then both models concur that TOT are not a major driver of the business cycles.

Note: to compute the share of variance the procedure consists on:
1. with tot_t as the whole driving process, compute the variance of output predicted by the MXN model.
2. Divide this value by the observed unconditional variance of output predicted by the SVAR model (variance of output when all shocks are active)
The same is done for the other variables.

Importance of Consistent Measuring of Variables between Empirical and Theoretical model

Suppose that instead of computing the predictions of the model in constant prices we would obtained them in units of current consumption (as can be a common practice).

In that case, variance of all variables is higher than in constant prices (over-predicting the variability). That may favor the conventional wisdom view where TOT shocks are important drivers of fluctuations.

TOT Disconnect

Median and average results showed suggest MXN model and the SVAR have similar implications with regards to the importance of the TOT shocks for aggregate movement in output.

However, when checking predictions at country level the conclusion is the opposite: when plotting the % of explained variance by country there are important differences between SVAR and MXN model. The match is good on average but is also poor at the individual level.

Conclusion

Conventional wisdom: TOT represent a major source of fluctuations for EMEs.

SVAR results: the explanatory role for TOT is modest.

MXN model results: with non-tradable goods the role is modest too.

This does not mean that world prices are not important shocks. TOT are a highly aggregated summary variable that may capture poorly the transmission mechanism of certain individual prices.

Tipically a country trades a large number of goods and services.

To test this further: Fernandez, Schmitt-Grohe, and Uribe (JIE,2017) estimate a variation of the SVAR in which the TOT is replaced by 3 world commodity prices. Then, jointly, these prices explain about 30% of the aggregate fluctuations.