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: $RER_t = \frac{\mathcal{E}_t P_t^*}{P_t}$ (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

Agents solve:

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

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

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

s.t.

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

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

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

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

d_t: External debt maturing in t

$r>0$ interest rate (constant)

FOCs:

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

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

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

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

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

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

Intuition: Consumption of NT (importables) will decrease (increase) w/ the 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 explains why authors 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. Now we split this price to link the RER to the price of non-tradables:

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

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

Market clearing

Non-tradable goods: $$c_t^n = y_t^n \quad (8)$$

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

Intertemporal Budget Constraint Analysis:

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

then given (3) we have $\lambda_t = \lambda \ \forall\ t$, then: $c_t^m = c^m$

Iterate the BC forward (to infinity) and use the TVC (5) to get:

$$c^m = -\frac{r}{1+r} d_0 + \frac{r}{1+r} \sum_{t=0}^{\infty} \frac{tot_t y^x}{(1+r)^t}. \quad (10)$$

The assumption ($\beta(1+r)=1$) and FOC wrt c_t^n also imply $c_t^n = c^n$

Then by (6) we get an expression for the Equilibrium RER: $$p^n = P\left(\frac{c^m}{y^n}\right) \quad (11)$$ $\uparrow p^n \equiv \downarrow RER$ (RER appreciates)

The RER appreciates when:
- Supply of non-tradables y^n falls ($\downarrow y^n$)
- Current TOT or supply of tradables increase ($\uparrow c^m, \uparrow tot_t, \uparrow y^x$)
- 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 (at y^n) its price increases to eliminate the excess demand.

Permanent Shock: tot_t increases for all $t \geq 0$.

Effect on RER:

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

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

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

Effect on Output:

Unexpected and permanent increase in tot at t=0

With non-tradables the output y_t is: $y_t = \frac{P^x_t y^x + P^n_t y^n}{P_t}$

Multiply/divide by P^m_t: $y_t = \frac{tot_t y^x + p^n_t y^n}{p^c_t}$

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

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

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

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

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

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 ($r_0 > r$): FOCs evaluated at t=0 imply that $c^m_1 > c^m_0$.

In addition it follows that c^m_0 falls wrt previous levels. Then: $\frac{\partial c_0}{\partial r_0} < 0$

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

$$\frac{\partial p^n_0}{\partial r_0} = P'\left(\frac{c^m_0}{y^n}\right)\frac{1}{y^n}\frac{\partial c^m_0}{\partial r_0} < 0$$

The 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 quadratic trend.

$\hat{tb}$: Trade balance divided by trend component of output and then removing a quadratic time trend

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

Data source: WDI

38 Countries (w/ at least 30 consecutive data points in all variables) Poor and EMEs, period: 1980-2011, Country-wise estimation

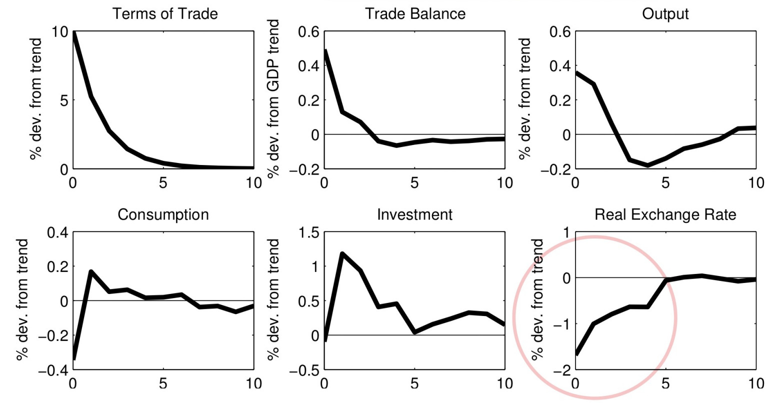
$\widehat{tot}_t = \rho\widehat{tot}_{t-1} + \sigma_{tot}\epsilon^{tot}_t$; $\epsilon^{tot}_t \sim (0, 1)$

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 an appreciation of the 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 average 10% of variance of output

Then this SVAR is also at odds w/ conventional wisdom indicating the 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 capital as input.

Factors are specific to each sector.

The Household Problem: Maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h^m_t, h^x_t, h^n_t)$$

subject to the period budget constraint

$$c_t + i^m_t + i^x_t + i^n_t + p^\tau_t d_t + \Phi_m(k^m_{t+1} - k^m_t) + \Phi_x(k^x_{t+1} - k^x_t) + \Phi_n(k^n_{t+1} - k^n_t) = \frac{p^\tau_t d_{t+1}}{1+r_t} + w^m_t h^m_t + w^x_t h^x_t + w^n_t h^n_t + u^m_t k^m_t + u^x_t k^x_t + u^n_t k^n_t,$$

Units: Final Goods

P^τ_t: Relative price of tradables

d_t: Debt due in t

and to the laws of motion for physical capital

$k^m_{t+1} = (1-\delta)k^m_t + i^m_t$; $k^x_{t+1} = (1-\delta)k^x_t + i^x_t$; $k^n_{t+1} = (1-\delta)k^n_t + i^n_t$.

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.
$a_t^\tau =$ 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.
$\chi_\tau =$ expenditure share on tradables if $\mu_{\tau n}$.

Tradable composite good firms:

$$\max\{p_t^\tau a_t^\tau - p_t^m a_t^m - p_t^x a_t^x\}$$

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

$a_t^\tau =$ 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:

$$\max_{h_t^m, k_t^m} \; p_t^m y_t^m - w_t^m h_t^m - u_t^m k_t^m$$

s.t. $$y_t^m = A_t^m (k_t^m)^{\alpha_m} (h_t^m)^{1-\alpha_m}$$

Check timing of capital
as choice variable: t or t+1?
in production fns: t-1 or t?

Exportable Good Firms:

$$\max_{h_t^x, k_t^x} \; p_t^x y_t^x - w_t^x h_t^x - u_t^x k_t^x$$

s.t. $$y_t^x = A_t^x (k_t^x)^{\alpha_x} (h_t^x)^{1-\alpha_x}$$

Non-Tradable Goods Firms:

$$\max_{h_t^n, k_t^n} \; p_t^n y_t^n - w_t^n h_t^n - u_t^n k_t^n$$

s.t. $$y_t^n = A_t^n (k_t^n)^{\alpha_n} (h_t^n)^{1-\alpha_n}$$

Interest Rate: Debt-elastic premium:

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

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												
$\frac{\sigma_i}{\sigma_y}$	$\frac{\sigma_{tb}}{\sigma_y}$	$\frac{\sigma_{im+ix}}{\sigma_{in}}$	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				

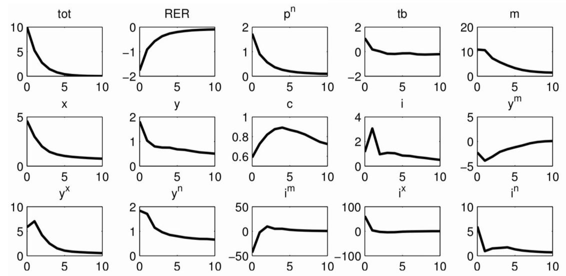
$*$ Country specific estimates $\quad \frac{\sigma_i}{\sigma_y}, \frac{\sigma_{tb}}{\sigma_y}$: Conditional on tot shocks $\quad s_n: p^n y^n / y \quad s_x: x/y \quad s_{tb}: (x-m)/y$

with: $y = p^m y^m + p^x y^x + p^n y^n$

Relevant parameters for checking the effect of the TOT shocks:

\rho and \sigma_{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 Exportable goods increases, of importable goods decreases. Production 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 we 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 computed 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 the variance of all variables is higher than in constant prices (over-predicting the variability)
That may lead to favor the conventional wisdom view where the TOT shocks are important drivers of fluctuations.

TOT Disconnect
The median and average results showed suggest the 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 the predictions at the country level the conclusion is the opposite: when plotting the share of explained variance by country there are important differences between the SVAR and the 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. **Model results:** with non-tradable goods the role is modest too.
This does not mean that world prices are not important transmitters of shocks. The TOT shocks are a highly aggregated summary variable that may capture poorly the transmission mechanisms 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 model in which the TOT is replaced by 3 world commodity prices. They find that jointly, these prices explain about 30% of the aggregate fluctuations