Summary Ch 7

Importable Goods, Exportable Goods, and Terms of Trade

Until now we assumed environments with a single good that was freely tradable and homogeneous across economies. In reality there are exportable, importable, tradable and not tradable consumption goods. Total consumption would be a combination of these.

In this chapter we include importable and exportable goods in the Open Economy Model.

Two important relative prices can be studied with these distinct goods: with imported and exported goods we can study **terms of trade,** and with tradable and non-tradable goods we study the **real exchange rate.**

Terms of trade (tot): relative price of exportable goods with respect to importable ones.
Real Exchange Rate (per): relative price of final consumption baskets between economies.

A relevant, non-trivial question is how the fluctuations in these relative prices drive or reflect the movements in macroeconomic variables.

For example, after an increase in tot we can expect higher nominal value of the same export sales (or lower imports), but also a decrease in the demand for exports as these become more relatively expensive. The net effect can be ambiguous. On the other hand, if the effect is positive in the value of exports, is possible that this leads to higher output, consumption and imports demand which offsets the effect of the higher exports on the net exports.

In this chapter: Terms of Trade (empirical and modelling approach)

$tot_t = \frac{P_t^x}{P_t^m}$ P^x: Prices of Exportables P^m: Prices of Importables

If $\Delta tot_t > 0$: the country experienced an improvement in the terms of trade

Empirical Model

Simple approximation: Univariate

Most countries have no impact on international prices. Then we can assume variations in TOT are exogenous (and a source of fluctuations).

As a first approximation assume the TOT follows an univariate process: $\widehat{tot}_t = \rho\,\widehat{tot}_{t-1} + \pi\epsilon_t^{tot}$; π: Std. dev of ϵ_t^{tot}, $\epsilon_t^{tot} \sim N(0,1)$

$\hat{tot}_t = tot_t - tot_t^{trend, quadratic}$

The AR(1) equation above is estimated for 51 economies (country-wise estimation), with period 1980-2011 and annual frequency. Data Source: WDI.

Results:

Country	ρ	π	R^2
Mean	0.50	0.10	0.30
Median	0.53	0.09	0.31
Interquartile Range	[0.41, 0.61]	[0.07, 0.11]	[0.19, 0.39]

TOT are moderately volatile (unconditional variance is 11%)

Shocks die quickly (half life is ln(1/2)/ln(rho)=1, i.e. one year)

Relatively homogeneous, with narrow IQ range for both rho and pi

Relation between TOT and Trade Balance (tb)

Whether an increase in the TOT leads to an improvement or deterioration in the TB is not trivial.

Empirical approach: joint AR process, SVAR.

Equation by equation approach:

$$\widehat{tot}_t = \rho\widehat{tot}_{t-1} + \pi\epsilon_t^1, \qquad (2)$$

$$\hat{tb}_t = \alpha_0\widehat{tot}_t + \alpha_1\widehat{tot}_{t-1} + \rho_2\hat{tb}_{t-1} + \sqrt{\sigma_{22}}\epsilon_t^2 \qquad (3)$$

This system is estimated by OLS, country by country, equation by equation, for 51 poor and emerging economies.

Identification: ϵ_t^1 is assumed to be a TOT shock.

Important: $\hat{tot}_t$ appears contemporaneously in (3), then the errors are orthogonal $(\epsilon_t^1 \perp \epsilon_t^2)$ (that is, ϵ_t^2 captures shocks other than TOT ones that affect the TB contemporaneously)

by assumption ϵ_t^2 is orthogonal to the rest of the regressors in the RHS of (2). Given that includes $\hat{tot}_t$, it follows $\epsilon_t^1 \perp \epsilon_t^2$

Associated SVAR system after replacing tot_t in the second equation:

$$\begin{bmatrix} \widehat{tot}_t \\ \hat{tb}_t \end{bmatrix} = h_x \begin{bmatrix} \widehat{tot}_{t-1} \\ \hat{tb}_{t-1} \end{bmatrix} + \Pi \begin{bmatrix} \epsilon_t^1 \\ \epsilon_t^2 \end{bmatrix} \quad (4); \quad h_x \equiv \begin{bmatrix} \rho & 0 \\ \alpha_0\rho + \alpha_1 & \rho_2 \end{bmatrix} \quad \text{and} \quad \Pi \equiv \begin{bmatrix} \pi & 0 \\ \alpha_0\pi & \sqrt{\sigma_{22}} \end{bmatrix}$$

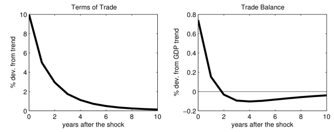
Result: (average of countries' estimations)

$$\begin{bmatrix} \widehat{tot}_t \\ \hat{tb}_t \end{bmatrix} = \begin{bmatrix} 0.50 & 0 \\ -0.02 & 0.57 \end{bmatrix} \begin{bmatrix} \widehat{tot}_{t-1} \\ \hat{tb}_{t-1} \end{bmatrix} + \begin{bmatrix} 0.10 & 0 \\ \boxed{0.008} & 0.032 \end{bmatrix} \begin{bmatrix} \epsilon_t^{tot} \\ \epsilon_t^{tb} \end{bmatrix}$$

Given Pi(2,1) = 0.008 > 0 it follows that a **positive TOT shock leads to an improvement in the TB**

Answer: *The trade balance improves in response to an increase in the terms of trade*

The effect is not too persistent:



Then, *an increase in the terms of trade causes a* ***short-lived*** *improvement in the trade balance*

Simple theoretical explanations:

HLM effect: (Harberger-Laursen-Metzler) An increase in TOT improves the TB.
This result is derived from a semi-structural (non-microfounded) Keynesian model.

ORS effect: (Obstfeld-Svensson-Razin) Effect of TOT on TB depends on persistence of TOT. The HLM effect (positive relationship) holds for low persistence TOT, but may be reverted for high levels of persistence.
This result is derived from a model consistent with optimal behavior.

HLM Effect from a classical model perspective

Positive relationship between tb_t and tot_t

Start w/ the national accounting identity $y_t = c_t + g_t + i_t + x_t - m_t$ (Units of variables: imports - P^m~1 -)

Now consider the behavioral equations: $g_t = \bar{g}$, $i_t = \bar{i}$, $c_t = \bar{c} + \alpha y_t$, $m_t = \mu y_t$, $\mu \in (0,1)$

w/ $\bar{g} + \bar{i} + \bar{c}$: autonomous component of domestic absorption. Let $\bar{q}$ be the quantity of exports. Then the exports, in units of import goods is: $x_t = tot_t \cdot \bar{q}$

The trade balance is: $tb_t = \frac{1-\alpha}{1+\mu-\alpha} tot_t \bar{q} - \frac{\mu(\bar{c}+\bar{i}+\bar{g})}{1+\mu-\alpha} \Rightarrow \frac{\partial tb_t}{\partial tot_t} = \frac{1-\alpha}{1+\mu-\alpha} \cdot \bar{q} > 0$

Intuition: $tot_t \uparrow \rightarrow x_t \uparrow \rightarrow y_t \uparrow \rightarrow c_t, m_t \uparrow \rightarrow y_t \uparrow \rightarrow c_t, m_t \uparrow$, but because $\alpha, \mu < 1$ m_t increases by less than x_t, so $tb_t \uparrow$

ORS Effect (Model)

Endowment Open Economy model. Households consume an importable good; Have 1 unit of the exportable good as endowments; Borrow or lend at rate r

Households solve: $\max_{\{c_t, d_t\}} \mathbb{E}_0 - \frac{1}{2}\sum_{t=0}^{\infty}\beta^t(c_t - \bar{c})^2$ s.t. $d_t = (1+r)d_{t-1} + c_t - tot_t$

From the FOCs and BC we know the tb_t is: $tb_t = rd_{t-1} + \frac{1-\rho}{1+r-\rho} tot_t$

In Chpt 2 we saw that in the context of AR(1) endowments the CA_t is equal to $\frac{1-\rho}{1+r-\rho}(y_t - \bar{y})$, now here $y_t = tot_t$ and $\overline{tot} = 0$ (From AR process). Then the tb (CA is tb (minus) plus returns on (debt) assets) is $tb_t = rd_{t-1} + \frac{1-\rho}{1+r-\rho} tot_t$

$\Rightarrow \frac{\partial tb_t}{\partial tot_t} = \frac{1-\rho}{1+r-\rho} > 0$ ORS effect: response of tb is weaker if tot is more persistent

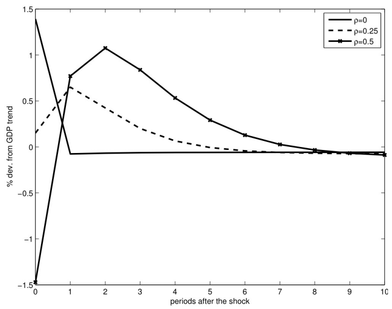
Intuition: a tot_t shock is a temporary income shock that drives up the agents' Savings (and not the consumption)

In SOE-RBC model: Assume consumption and investment are imported goods and output is exportable. Then assuming no TFP Shocks, output in terms of importable goods is $tot_t \cdot F(k_t, h_t)$

the trade balance is: $tb_t = tot_t F(k_t, h_t) - c_t - i_t - \phi(k_{t+1} - k_t)$

the resulting model is identical to the standard SOE-RBC (Ch 4) with A_t renamed tot_t

SOE-RBC model (IRFs) supports to ORS effect



Why?: Persistence of tot_t induces persistence of output (tot_t behaves as a TFP)

Making investment more productive w/ higher investment (and savings) the tb_t falls

(Same reasoning that makes the SOE-RBC a better alternative than the endowment model to obtain a countercyclical tb_t)

Nonetheless the empirical tests based on the SVAR from before do not seem to support the ORS effect.
Then we should do more empirical and theoretical tests.

How important are the TOT shocks

Empirical approach (SVAR, 5 variables) $\longrightarrow$ before: SVAR w/ tot, tb ; Now: Extend to include macro variables

Variables: terms of trade (tot_t), trade balance (tb_t), output (y_t)

let $x_t = \begin{bmatrix} x_t^1 \\ x_t^2 \end{bmatrix}$, $x_t^1 = \hat{tot}_t$, $x_t^2 = \begin{bmatrix} \hat{tb}_t \\ \hat{y}_t \\ \hat{c}_t \\ \hat{i}_t \end{bmatrix}$

SVAR Equations

$$x_t^1 = \rho x_{t-1}^1 + u_t^1 \qquad (6)$$

$$x_t^2 = \alpha_0 x_t^1 + \alpha_1 x_{t-1}^1 + \beta_2 x_{t-1}^2 + u_t^2 \qquad (7)$$

w/ $E(u_t^1)^2 = \pi^2$, $E(u_t^2 u_t^{2'}) = \Sigma$

Identification assumptions

tot is an AR(1) process. Then error of equation is a tot shock.

other variables are affected by tot contemporaneously (and by lags of all variables)

Dimensions: α_0, α_1: 4x1, β_2: 4x4, π: 1x1, Σ: 4x4

Restrictions implied by the identification

$$\underbrace{\begin{bmatrix} u_t^1 \\ u_t^2 \end{bmatrix}}_{\text{Non Structural Shocks}} = \begin{bmatrix} \gamma_{11} & \cancel{\gamma_{12}} \\ \cancel{\gamma_{21}} & \gamma_{22} \end{bmatrix} \underbrace{\begin{bmatrix} \epsilon_t^1 \\ \epsilon_t^2 \end{bmatrix}}_{\text{Structural Shocks}}$$

$\gamma_{12} = 0$ by assumption

$\gamma_{21} = 0$ because $E u_1 u_2 = 0$ given u_1 is a TOT shock and the tot is a regressor in the equation of x_t^2 (7)

then $u_t^1 = \gamma_{11} \epsilon_t^1$, $u_t^2 = \gamma_{22} \epsilon_t^2 \Rightarrow \gamma_{11} = \pi$, $\gamma_{22}\gamma_{22}' = \Sigma$

SVAR (single equation)

The system (6), (7) can be written as:

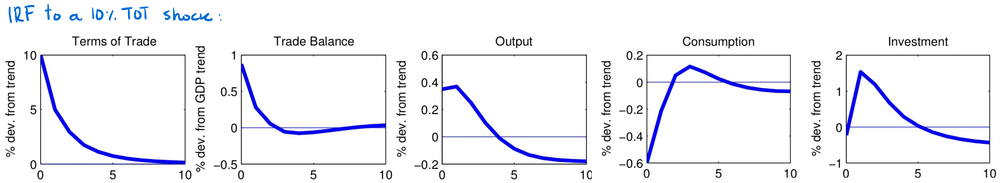
$$x_t = h_x x_{t-1} + \Pi \epsilon_t$$

w/ $h_x = \begin{bmatrix} \rho & 0 \\ \alpha_0 \rho + \alpha_1 & \beta_2 \end{bmatrix}$ and $\Pi = \begin{bmatrix} \pi & 0 \\ \alpha_0 \pi & \gamma_{22} \end{bmatrix}$, γ_{22}: lower triangular Cholesky of Σ (any γ_{22} s.t. $\gamma_{22}\gamma_{22}' = \Sigma$ works here as we are only interested in identifying the TOT shock)

Estimation: (6) and (7) are estimated equation by equation and country by country (i.e. this is a SVAR, not a panel SVAR)

Then, we obtain country-level estimates of the parameters: $\rho, \pi, \alpha_0, \alpha_1, \beta_2, \Sigma$

IRF to a 10% TOT shock:



IRF Interpretation:
- On impact: y increases, tb increases by more, i does not react. Then c falls to compensate extra exports growth.
- TB: improves, then the HLM effect is supported

y will expand for 3 years, consumption recovers quickly after initial drop. Investment expands but with a delay

Share of variance of each variable explained by TOT shock:

Country	tot	tb	y	c	i
Cross-Country Mean	100	18	12	13	13
Cross-Country Median	100	12	10	11	10
Median Absolute Deviation	0	11	9	9	8
Using Cross-Country Mean of h_x and Π	100	7	3	1	2
Panel Estimation	100	4	1	1	1

- TOT shocks explain a small share (10% to 12%) of variances of y, tb, c, i
- Result is robust to estimating shares w/ 3 methods
- There is significant cross-country variation

(hunch w/ tb: opposing and coexisting effects of ΔTOT on TB)

Theoretical approach
MX model

One (homogeneous) good approach can be problematic (too simplistic): implicitly assumes 100% of the GDP is exported and 100% of the consumption and investment is imported (tb_t = y_t - c_t - i_t usually).

(This is why in the endowment model we assumed y was given in exports units and the rest in imports)

Here we extend the framework: two goods model, one importable, one exportable. Both are produced, consumed and used to produce investment goods.

Households

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

subject to

$$c_t + i_t^m + i_t^x + \Phi_m(k_{t+1}^m - k_t^m) + \Phi_x(k_{t+1}^x - k_t^x) + d_t$$
$$= \frac{d_{t+1}}{1+r_t} + w_t^m h_t^m + w_t^x h_t^x + u_t^m k_t^m + u_t^x k_t^x,$$
$$k_{t+1}^m = (1-\delta)k_t^m + i_t^m, \qquad (9)$$

and

$$k_{t+1}^x = (1-\delta)k_t^x + i_t^x, \qquad (10)$$

FOCs:

$[c_t]$: $$U_1(c_t, h_t^m, h_t^x) = \lambda_t, \qquad (11)$$

$[h_t^m]$: $$-U_2(c_t, h_t^m, h_t^x) = \lambda_t w_t^m, \qquad (12)$$

$[h_t^x]$: $$-U_3(c_t, h_t^m, h_t^x) = \lambda_t w_t^x, \qquad (13)$$

$[d_{t+1}]$: $$\lambda_t = \beta(1+r_t)E_t\lambda_{t+1}, \qquad (14)$$

$[k_{t+1}^m]$: $$\lambda_t\left[1 + \Phi_m'(k_{t+1}^m - k_t^m)\right] = \beta E_t \lambda_{t+1}\left[u_{t+1}^m + 1 - \delta + \Phi_m'(k_{t+2}^m - k_{t+1}^m)\right], \qquad (15)$$

and

$[k_{t+1}^x]$: $$\lambda_t\left[1 + \Phi_x'(k_{t+1}^x - k_t^x)\right] = \beta E_t \lambda_{t+1}\left[u_{t+1}^x + 1 - \delta + \Phi_x'(k_{t+2}^x - k_{t+1}^x)\right]. \qquad (16)$$

In SS the rental rates of capital are equalized (No adj. costs)

y^m can only be produced w/ h^m, k^m
y^x " " " " " h^x, k^m

Sectoral K adjustment cost and imperfect substitutability of sector-specific labor are meant to slow down sectoral factor reallocations.

Firms (final goods)

final good is produced w/ an armington aggregator of importable and exportable goods

The final goods producer solves $\max_{a_t^m, a_t^x} A(a_t^m, a_t^x) - p_t^m a_t^m - p_t^x a_t^x$

$A(a_t^m, a_t^x)$: Armington Aggregator (final good)
a_t^m: Importables used as input
a_t^x: Exportables used as input

FOCs:

$[a_t^m]$: $$A_1(a_t^m, a_t^x) = p_t^m, \qquad (17)$$

$[a_t^x]$: $$A_2(a_t^m, a_t^x) = p_t^x. \qquad (18)$$

Production of Intermediate goods (exportables, importables)

The technology is given by:

$$y_t^m = F^m(k_t^m, h_t^m) \qquad (19)$$

$$y_t^x = F^x(k_t^x, h_t^x), \qquad (20)$$

Each type of producer solves: $\max_{k_t^j, h_t^j} \; p_t^j F^j(k_t^j, h_t^j) - w_t^j h_t^j - u_t^j k_t^j$.

FOCs:

$[k_t^m]$: $$p_t^m F_1^m(k_t^m, h_t^m) = u_t^m, \qquad (21)$$

$[h_t^m]$: $$p_t^m F_2^m(k_t^m, h_t^m) = w_t^m, \qquad (22)$$

$[k_t^x]$: $$p_t^x F_1^x(k_t^x, h_t^x) = u_t^x, \qquad (23)$$

$[h_t^x]$: $$p_t^x F_2^x(k_t^x, h_t^x) = w_t^x. \qquad (24)$$

Market Clearing

Final Goods Mkt: $$c_t + i_t^m + i_t^x + \Phi_m(k_{t+1}^m - k_t^m) + \Phi_x(k_{t+1}^x - k_t^x) = A(a_t^m, a_t^x). \qquad (25)$$

Dynamics of debt: (BOP definition) $$\frac{d_{t+1}}{1+r_t} = d_t + m_t - x_t, \qquad (26)$$

Imports and Exports definition: $$m_t = p_t^m(a_t^m - y_t^m) \qquad (27)$$

$$x_t = p_t^x(y_t^x - a_t^x). \qquad (28)$$

Other Features and definitions to close the model

Terms of Trade (def): $$tot_t = \frac{p_t^x}{p_t^m}. \qquad (29)$$

Dynamics of TOT (and shock): $$\ln\left(\frac{tot_t}{tot}\right) = \rho \ln\left(\frac{tot_{t-1}}{tot}\right) + \pi \epsilon_t^{tot}, \qquad (30)$$

Interest rate (EDEIR to induce stationarity) $$r_t - r^* = p(d_{t+1}), \qquad (31)$$

Equilibrium (Def): $c_t, h_t^m, h_t^x, d_{t+1}, i_t^m, i_t^x, k_{t+1}^x, a_t^m, a_t^x, p_t^x, y_t^x, p_t^m, y_t^m, r_t^m, w_t^m, w_t^x, u_t^x, u_t^m, \lambda_t, m_t, x_t$ and tot_t

Satisfying equations (9)-(31), given initial conditions K_0^m, K_0^x, d_0, and tot_{-1}, and the stochastic process ϵ_t^{tot}.

Observables: Creation of theoretical counterparts of data (for comparisons)

Given this is no longer a model that is completely set in real terms we have to create a data-consistent GDP (in the model).

In data (WDI): Real GDP = Nominal GDP / Paasche Price deflator

let P_t^m: Nominal price of importable goods, P_t^x: Nominal price of exportable goods, P_t^c: Nominal price of consumption, P_t: Price level given by GDP deflator

then: real GDP: $$y_t^{real} = \frac{P_t^m y_t^m + P_t^x y_t^x}{P_t}, \text{ with: } P_t = \frac{P_t^m y_t^m + P_t^x y_t^x}{P_0^m y_t^m + P_0^x y_t^x}$$

i.e. real gdp is equal to nominal gdp over price level, the latter is given by the gdp deflator (base year: 0)

(why doing all of this? → the model does not say anything about P variables, but it does include 'p' ones)

Subst. P_t: $$y_t^{real} = P_0^m y_t^m + P_0^x y_t^x$$

Scale it by a constant (P_0^c): $$y_t^{real} = p_0^m y_t^m + p_0^x y_t^x, \quad w/ \quad p_0^j = \frac{P_0^j}{P_0^c}$$

Change base year to the Steady State: $$y_t^{real} = y_t^{obs} = p^m y_t^m + p^x y_t^x$$

Similar theoretical counterparts should be found for the other observables (Consumption, investment, tb) before comparing the results of the model and the data.

For example for consumption, the theoretical counterpart is given by the ratio of nominal consumption $P_t^c c_t$ to the gdp deflator: $$c_t^o = c_t \frac{p^m y_t^m + p^x y_t^x}{p_t^m y_t^m + p_t^x y_t^x}$$

Functional Forms for Preferences and Technologies

GHH preferences

$$U(c, h^m, h^x) = \frac{[c - G(h^m, h^x)]^{1-\sigma} - 1}{1-\sigma}; \quad \sigma > 0$$

Imperfect substitutability of sectoral employment

$$G(h^m, h^x) = \frac{(h^m)^{\omega_m}}{\omega_m} + \frac{(h^x)^{\omega_x}}{\omega_x}; \quad \omega_m, \omega_x > 0.$$

Cobb-Douglas technologies in the importable and exportable sectors

$$F^i(k^i, h^i) = A^i \left(k^i\right)^{\alpha_i} \left(h^i\right)^{1-\alpha_i}; \quad i = m, x; A^i > 0, \alpha_i \in (0,1).$$

Exponential debt-elastic country premium

$$p(d) = \overline{p} + \psi\left(e^{d-\overline{d}} - 1\right); \quad \psi \geq 0.$$

Quadratic capital adjustment costs,

$$\Phi_i(x) = \frac{\phi_i}{2}x^2, \quad i = m, x, \phi_i \geq 0.$$

CES Armington aggregator of importable and exportable goods,

$$A(a_t^m, a_t^x) = \left[\chi\left(a_t^m\right)^{1-\frac{1}{\mu}} + (1-\chi)\left(a_t^x\right)^{1-\frac{1}{\mu}}\right]^{\frac{1}{1-\frac{1}{\mu}}}; \quad \mu > 0, \chi \in (0,1).$$

Parametrization

Parameter values common to One-sector models

Calibrated Structural Parameters

σ	δ	r^*	$\overline{p}$	α_m, α_x	ω_m, ω_x	tot	A^m	β
2	0.1	0.04	0.07	0.32	1.455	1	1	$(1+r^*+\overline{p})^{-1}$

Parameter values based on sectoral Output and Trade data

μ	χ	$\overline{d}$	A^x
1	0.7399	0.0103	0.9732

μ: quarterly estimates $\mu < 1$, multi-year (5-10) estimates $\mu > 1$. Then for annual a middle point is chosen.

$\chi, \overline{d}, A^x$: match observed averages across time and countries of the share of trade balance in GDP ($s_{tb} = 0.01$), the share of exports in GDP ($s_x = 0.21$), and share of exportable output in GDP ($s_{yx} = 0.47$)

Parameter values estimated country by country to match observed second moments

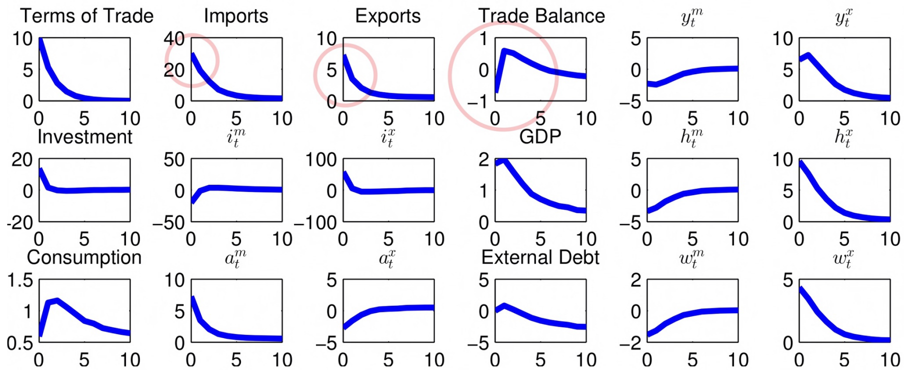
ρ	π	ϕ_m	ϕ_x	ψ
0.53	0.09	1.82	1.56	0.18

Note: Medians of cross-country estimations

ρ, π: estimated using country-specific terms of trade data from the WDI

ϕ_m, ϕ_x, ψ: Estimated by requiring model to match investment-output volatility ratio and trade-balance-output volatility ratio

Impulse Responses to a Ten-Percent Improvement in the Terms-of-Trade in the MX Model



Note. All variables except for the trade balance and external debt are expressed in percent deviations from steady state. The trade balance and external debt are expressed in level deviations from steady state in percent of steady-state output. Cross-country medians.

Substitution in production away from importable goods and toward exportable goods.
Substitution effect on domestic absorption in favor of importable goods.
Higher imports: due to increased in demand for importables together with with lower sectorial production.
Higher exports: due to lower demand for exportables together with higher sectorial production.
Trade Balance: Ambiguous effect due to both exports and imports increasing (in figure the median effect is negative), then the model fails to capture the HLM effect.
Increase in aggregate output, consumption and investment.

How important are the TOT shocks

Share of explained variance: **percentage explained by MX model is twice that of the SVAR.**
Then, the TOT matter more in theory than in practice.

The reported importance of the TOT is even higher in Mendoza (1995) and Kose (2002).

Variable	MX Model (1)	Empirical SVAR Model (2)
Terms of Trade	100	100
Trade Balance	27	12
Output	18	10
Consumption	24	11
Investment	20	10

Possible reason for MX model to overstate importance of TOT as driver of fluctuations:

MX assumes that all goods are perfectly Tradable.
⇒ Now we extend the model to include Non-Tradable goods.

How to reconcile the theory and data?

A problematic assumption of the MX model is that all goods are tradable.

This implies the model may tend to overstate the international flow of goods and services, which in turn may amplify the dynamic effects of a change in the TOT.

In reality about 2/3 of the goods are
not tradable. Then in the next chapter, the model is expanded to include non-tradable goods.