Summary Ch 7

Importable Goods, Exportable Goods, and Terms of Trade

Until now we assumed a single, freely tradable, and homogenous good. In reality there are exportable, importable, tradable and not tradable consumption goods. Total consumption should 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 (rer): relative price of final consumption baskets between economies.

Relevant question: how fluctuations in these prices drive the movements in macroeconomic variables

For example, after an increase in tot we can see a higher nominal value of the same export sales, but also a decrease in the demand for exports as they are more expensive. The net effect can be ambiguous. Similarly, if the value of net exports increases, it is possible to end up with a 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)

$tot_t = \frac{P_t^x}{P_t^m}$ $\quad P^x$: Prices of Exportables $\quad P^m$: 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: $\widehat{tot}_t = \rho\,\widehat{tot}_{t-1} + \pi\epsilon_t^{tot}$

w/ $\widehat{tot}_t = tot_t - tot_t^{\text{Trend, quadratic}}$

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)

Homogeneous, narrow IQ range for parameters

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:

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

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

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: $\widehat{tot}_t$ 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 regressors in RHS of (2); that includes $\widehat{tot}_t \longrightarrow \epsilon_t^1 \perp \epsilon_t^2$

Associated SVAR system after replacing tot_t in the second equation:

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

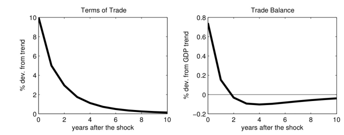
Result: (average of countries' estimations)

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

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. HLM effect (positive) holds for low persistence TOT, but may be reverted for high levels of persistence. Microfounded approach.

HLM effect from a classical model perspective:

Positive relationship between TB and TOT.
Start with the National accounting identity, $y_t = c_t + g_t + i_t + x_t - m_t$ (units of variables $- P^m_{\sim} 1 -$)

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

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

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

ORS effect model

Endowment Open Economy model: households consume an importable good; have 1 unit of the exportable good as endowment, 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 FOCs and BC we know tb_t is: $tb_t = r d_{t-1} + \frac{1-\rho}{1+r-\rho} tot_t$

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

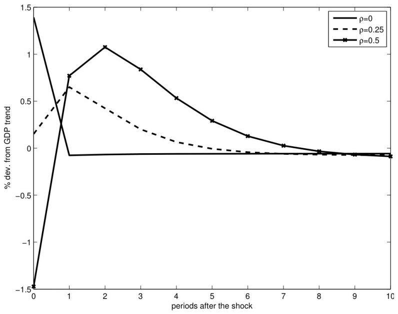
In Chpt 2 we saw that in the context of AR(1) endowments the CA_t is equal to $\frac{1-\rho}{1+r-\rho}(y_t - \bar{y})$, now here $y_t = tot_t$ and $\overline{tot} = 0$ (from AR process). Then the tb (CA is tb plus (minus) returns on (debt) assets) is $tb_t = r d_{t-1} + \frac{1-\rho}{1+r-\rho} tot_t$

Intuition: TOT shock is a temporary income shock that drives up HH savings (but not 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 $tot_t . F(k_t, h_t)$
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 the ORS effect



Why? Persistence of TOTt induced persistence of output (TOT behaves like a TFP) making investment more productive w/ higher investment (and savings) the TBt falls.

(Same reasoning making SOE-RBC better than endowment model for generating Countercyclical TBt)

Nonetheless, empirical tests based on SVAR (from before) are not supporting the ORS effect.
We must dig further then (e.g., include more variables).

How important are the TOT shocks

$\longrightarrow$ before: SVAR w/ tot, tb;
Now: Extend to include macro variables
Variables: tot_t, tbt_t, output (y_t), c_t, i_t

Empirical approach (SVAR, 5 variables)

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

Identification assumptions
tot is an AR(1) process $\Rightarrow$ error of equation is a tot shock.
Other variables are affected by tot contemporaneously
(& by lags of all variables)

SVAR Equations

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

$$x_t^2 = \alpha_0 x_t^1 + \alpha_1 x_{t-1}^1 + \rho_2 x_{t-1}^2 + u_t^2 \qquad (7)$$

w/ $E(u_t^1)^2 = \pi^2$, $E(u_t^2 u_t^{2\prime}) = \Sigma$
Dimensions: α_0, α_1: 4x1, ρ_2: 4x4, π: 1x1, Σ: 4x4

Restrictions implied by the identification

$$\underbrace{\begin{bmatrix} u_t^1 \\ u_t^2 \end{bmatrix}}_{\text{Non Structural Shocks}} = \begin{bmatrix} \gamma_{11} & \cancel{\gamma_{12}}^{\,0} \\ \cancel{\gamma_{21}}^{\,0} & \gamma_{22} \end{bmatrix} \underbrace{\begin{bmatrix} \epsilon_t^1 \\ \epsilon_t^2 \end{bmatrix}}_{\text{Structural Shocks}}$$

$\gamma_{12} = 0$ 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: $x_t = h_x x_{t-1} + \Pi \epsilon_t$

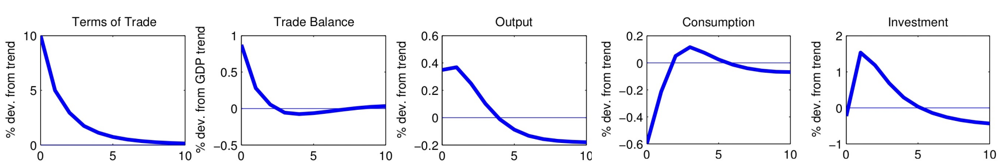
$$h_x = \begin{bmatrix} \rho & 0 \\ \alpha_0\rho + \alpha_1 & \rho_2 \end{bmatrix}, \quad \Pi = \begin{bmatrix} \pi & 0 \\ \alpha_0\pi & \gamma_{22} \end{bmatrix},$$

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, country-level estimates of parameters are obtained: $\rho_1, \pi, \alpha_0, \alpha_1, \rho_2, \Sigma$

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 explain a small share of variances of tb, c, i, y (10-12%)
- Result is robust to using 3 methods
- Significant country variation

(Hunch w/ TB: opposing & coexisting effect of TOT 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)

Extension: 2 goods, 1 importable, 1 exportable. Both produced, consumed and used to produce investment goods

Households:

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

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

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

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

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

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

Sectorial K adj. cost and imperfect substitability of sector-specific labor help slow down factor reallocations

Firms (final good)

Final good is produced w/ Armington aggregator of importable and exportable goods

The final good firm solves: $\max_{a_t^m, a_t^x} A(a_t^m, a_t^x) - p_t^m a_t^m - p_t^x a_t^x$

FOCs:

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

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

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

Production of Intermediate goods (exportables, importables)

The technology is given by:
$$y_t^m = F^m(k_t^m, h_t^m) \tag{19}$$
$$y_t^x = F^x(k_t^x, h_t^x), \tag{20}$$

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:

$[K_t^m]$: $$p_t^m F_1^m(k_t^m, h_t^m) = u_t^m, \tag{21}$$
$[h_t^m]$: $$p_t^m F_2^m(k_t^m, h_t^m) = w_t^m, \tag{22}$$
$[K_t^x]$: $$p_t^x F_1^x(k_t^x, h_t^x) = u_t^x, \tag{23}$$
$[h_t^x]$: $$p_t^x F_2^x(k_t^x, h_t^x) = w_t^x. \tag{24}$$

Market clearing:

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

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

Imports and Exports definition:
$$m_t = p_t^m(a_t^m - y_t^m) \tag{27}$$
$$x_t = p_t^x(y_t^x - a_t^x). \tag{28}$$

Other features to close the model:

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

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

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

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

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

Given the model is no longer completely set in real terms we must create a data-consistent GDP.

In data (WDI): Real GDP = Nominal GDP/Passche 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

$\Rightarrow$ real GDP: $y_t^{real} = \dfrac{P_t^m y_t^m + P_t^x y_t^x}{P_t}$, w/ $P_t = \dfrac{P_t^m y_t^m + P_t^x y_t^x}{P_0^m y_t^m + P_0^x y_t^x}$

Real GDP is equal to nominal GDP over price level,the latter is given byte GDP deflator (base year 0)

(Why to do all of this?: because the model does not say anything about P variables, but it does include the "p" ones -relative prices-)

Substitute Pt: $y_t^{real} = P_0^m y_t^m + P_0^x y_t^x$

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

Change base year to 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 to the data.

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

Parameters 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 the share of exportable output in GDP ($S_{yx} = 0.47$)

Parameter values estimated country-by-country to match observed second moments

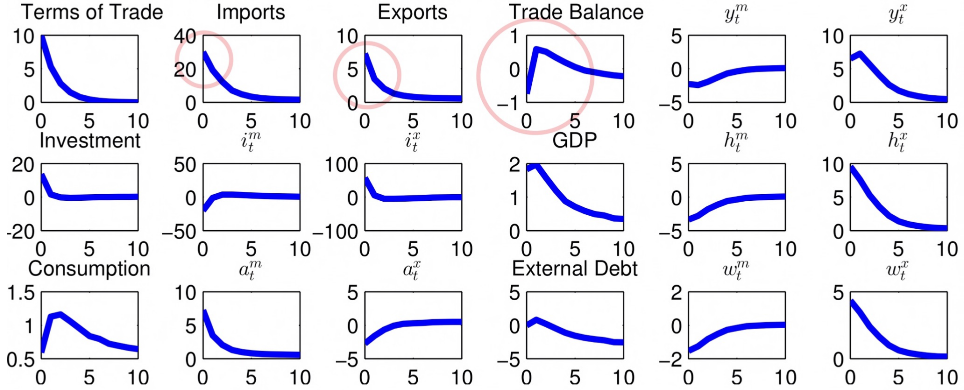
ρ	π	ϕ_m	ϕ_x	ψ
0.53	0.09	1.82	1.56	0.18

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-to-output volatility

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 fig. 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 all goods are perfectly tradable

Model should be extended 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 tends 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.
Next chapter: MX model is expanded to include non-tradable goods.