ECON 6356
International Finance and Macroeconomics

Lecture 4 (part 3): Non-tradable Goods and the Real Exchange Rate

Camilo Granados
University of Texas at Dallas
Fall 2023

Princeton University Press, 2017

slides

chapter 8

Nontradable Goods And

The Real Exchange Rate

These slides are an adjusted version of the materials for Chapter 8 of the OEM book provided by the authors

Introduction

MX model overestimates the role of TOT shocks: they explain 20% of the variance macro indicators versus only 10% in an estimated SVAR model.

One possible explanation: MX model unrealistically assumes that all goods are internationally traded (either importable or exportable).

In reality, the bulk of goods falls into a third category: **Nontradables.**

Nontradables: Goods that are exclusively produced and absorbed domestically. Reasons for nontradability: Transportation costs, trade barriers,etc.

Here a SOE model with nontradable goods is set to explore the role of this type of goods in transmitting aggregate disturbances.

The Real Exchange Rate

Real exchange rate (RER_t): Relative price of consumption goods baskets across countries. Formally,

$$RER_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t}, \tag{1}$$

- P_t^*: Nominal price of consumption in the foreign country in units of foreign currency,
- P_t: Nominal price of consumption in the domestic country in units of domestic currency,
- $\mathcal{E}_t$: Nominal exchange rate (NER or ER), defined as the price of one unit of foreign currency in terms of domestic currency.

• When RER_t **increases**, the domestic economy becomes cheaper relative to the foreign economy, and we say that the **real exchange rate depreciates**.

• When RER_t **falls**, the domestic economy becomes more expensive relative to the foreign economy, and we say that the **real exchange rate appreciates**.

• For Intuition, check the units: $\frac{\frac{\text{Local currency}}{\text{Foreign currency}} \times \frac{\text{Foreign currency}}{\text{Foreign good}}}{\frac{\text{Local currency}}{\text{Local good}}} = \frac{\text{Local good}}{\text{Foreign good}}$: how many units of local goods (cons. basket) you have to give in exchange for a unit of foreign goods.

The TNT Model

The tradable-nontradable (TNT) model is an endowment open economy model with **one good that is fully imported** (not domestically produced), **one good that is fully exported** (not domestically consumed), and **one nontradable good**.

It is a useful structure because it allows us to understand in a simple environment how different disturbances affect the real exchange rate.

The predictions of the TNT model extend to more complex environments, which adds to its theoretical appeal.

The Representative Household

Households are infinitely lived and choose sequences $\{c_t^m, c_t^n, d_{t+1}\}_{t=0}^{\infty}$ to maximize

$$\sum_{t=0}^{\infty} \beta^t U(c_t),$$

subject to

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

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

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

where c_t is consumption; c_t^m and c_t^n are consumption of importables and non-tradables, respectively and $A(\cdot, \cdot)$ is increasing, concave, and HD1; d_t is external debt maturing in t; $r > 0$ is the interest rate; tot_t is the terms of trade; y^x and y^n are constant endowments of exportables and nontradables.

Note that c_t^m is fully imported and y^x is fully exported.

Optimality Conditions

The FOCs are the sequential budget constraint and

$$U'(c_t)A_1(c_t^m, c_t^n) = \lambda_t, \tag{2}$$

$$\lambda_t = \beta(1+r)\lambda_{t+1}, \tag{3}$$

$$p_t^n = \frac{A_2(c_t^m, c_t^n)}{A_1(c_t^m, c_t^n)}, \tag{4}$$

$$\lim_{j\to\infty}(1+r)^{-j}d_{t+j} = 0. \tag{5}$$

Because $A(\cdot,\cdot)$ is increasing, HD1, and concave, we can rewrite the optimality condition (4) as

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

Intuition: If nontradables become more expensive relative to importables, households consume relatively less nontradables and more importables.

Real Exchange Rate and the Relative Price of Nontradables

In this model there is a **one-to-one relationship between the relative price of nontradables, p_t^n, and the real exchange rate, RER_t.**

To see this, divide the numerator and denominator of the RHS of (1) by the nominal price of the importable good, denoted P_t^m, to obtain

$$RER_t = \frac{\mathcal{E}_t P_t^* / P_t^m}{P_t / P_t^m}.$$

Assume that the *law of one price* holds for importable goods

$$P_t^m = \mathcal{E}_t P_t^{m*}.$$

Then, letting $p_t^c \equiv P_t / P_t^m$ and $p_t^{c*} \equiv P_t^* / P_t^{m*}$ denote the relative prices of consumption domestically and abroad, we can write $RER_t = p_t^{c*} / p_t^c$.

Note that p_t^{c*} is exogenously determined; assume that it is constant and normalized to unity, $p_t^{c*} = 1$. Then we have

$$RER_t = \frac{1}{p_t^c}. \tag{7}$$

It remains to link p_t^c to p_t^n. To this end, let's **decentralize the market for final consumption goods.**

Firms producing c_t choose inputs c_t^m and c_t^n to maximize profits

$$p_t^c A(c_t^m, c_t^n) - c_t^m - p_t^n c_t^n.$$

The FOC with respect to c_t^m is

$$p_t^c A_1(c_t^m, c_t^n) = 1.$$

Finally, combine this with (6) and (7) to get $RER_t = A_1\left(P^{-1}(p_t^n), 1\right)$. So we can write

$$RER_t = e(p_t^n); \quad \text{with } e'(\cdot) < 0.$$

- **RER appreciates** if and only if the relative price of nontradables **increases**.
- **RER depreciates** if and only if the relative price of nontradables **decreases**.

For this reason, many economists use the terms real exchange rate and relative price of nontradables interchangeably.

Intuition: if $p_t^n \uparrow$ foreign consumption basket gets cheaper relative to the home one ($RER \downarrow$)

Market Clearing

The quintessential property of nontradable goods is that they are produced and consumed domestically:

$$c_t^n = y^n, \tag{8}$$

By contrast, the gap between production and consumption of tradables is bridged by foreign trade in goods and assets:

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

The Equilibrium Real Exchange Rate

Iterating the resource constraint (8) forward ad infinitum and using the transversality condition (5) yields

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

Finally, assume that $\beta(1+r) = 1$. Then, (2), (3), and (8) imply that importable consumption is constant, $c_t^m = c^m$. Thus we can write

$$p^n = P\left(\frac{c^m}{y^n}\right) \tag{11}$$

Taken together, (10) and (11) say that the equilibrium RER appreciates (i.e., the economy becomes more expensive vis-à-vis the rest of the world) when:

(a) The supply of nontradables falls;

(b) The current TOT improve or the current supply of tradables increases;

(c) The TOT are expected to improve or the supply of tradables expected to increase in the future.

Adjustment of the RER to Temporary TOT Shocks

Assume that tot_0 increases, while tot_t remains unchanged for all $t > 0$. From (10) and (11) we have that

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

Intuition: Increase in relative price of the endowment creates a positive income effect $\Rightarrow$ households increase their demand for all consumption goods (importables, nontradables). But supply of nontradables is fixed $\Rightarrow p^n \uparrow$.

Relative price of nontradables $\uparrow \Rightarrow RER_t \downarrow$ (appreciates)
(domestic economy becomes more expensive relative to the rest of the world)

Adjustment of the RER to Permanent TOT Shocks

Assume now that tot_t increases for all $t \geq 0$. Then equilibrium conditions (10) and (11) imply that

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

The intuition is the same as with temporary shocks.

However, permanent changes in the TOT have a stronger effect on p^n

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

Intuition: The **more permanent** is the increase in TOT, the **larger the income effect**, and thus, the larger the increase in the demand for nontradables.

The latter, in turn, implies a larger increase in the relative price of nontradables. (higher RER appreciation)

Adjustment of the RER to Interest-Rate Shocks

Temporary shock: one-time increase to $r_0 > r$ and then it returns to r.

It can be shown that this causes a contraction in consumption of importables,

$$\frac{\partial c_0^m}{\partial r_0} < 0.$$

Intuition: With a high interest rate it is a good to save more and consume less. This expression together with (6) and (8) implies that

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

$\Rightarrow$ RER depreciates ($\uparrow$) in response to a temporary interest rate increase.

Intuition: households want to consume less of all goods. But supply of non-tradables is fixed $\Rightarrow$ price of nontradables must fall to clear the market ($p^n \downarrow$).

Adjustment of Output to Terms-of-Trade Shocks

We saw the MX model overestimates the role of TOT shocks as fluctuations drivers. Can introducing nontradables ameliorate this problem?

Output, denoted y_t, is given by

$$y_t = \frac{P_t^x y^x + P_t^n y^n}{P_t},$$

where P_t^x, P_t^n, and P_t denote, respectively, the nominal prices of exportables, nontradables, and final goods. Divide the numerator and denominator by the nominal price of importables to get

$$y_t = \frac{tot_t y^x + p_t^n y^n}{p_t^c}.$$

Recalling that $p_t^c = 1/A_1(c_t^m, y^n)$ and that $p_t^n = A_2(c_t^m, y^n)/A_1(c_t^m, y^n)$

$$y_t = A_1(c_t^m, y^n) tot_t y^x + A_2(c_t^m, y^n) y^n. \tag{12}$$

(The argument continues in the next slide.)

Adjustment of Output to Terms-of-Trade Shocks (continued)

Assume that there is an unexpected permanent increase in TOT in period 0.

Suppose the aggregator function takes a CD form $A(c^m, y^n) = (c^m)^\alpha (y^n)^{1-\alpha}$, with $\alpha \in (0, 1)$. Then equation (12) becomes

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

which implies that $\left.\dfrac{\partial y_0}{\partial tot}\right|_{1-\alpha=0} = y^x > 0$ and $\left.\dfrac{\partial y_0}{\partial tot}\right|_{1-\alpha=1} = 0,$

$\Rightarrow$ as the share of nontradables in total expenditure increases from zero to 100 percent, the output effect of a TOT shock falls from a positive value to zero.
(The relationship between the share of nontradables in consumption and the effect in the terms of trade is in general nonmonotonic.)

Empirical Evidence on the Effects of TOT Shocks on the RER and Aggregate Activity

A Structural Vector Autoregressive (SVAR) Model

- Let $x_t = \left[\ \widehat{tot}_t,\ \ \widehat{tb}_t,\ \ \widehat{y}_t,\ \ \widehat{c}_t,\ \ \widehat{i}_t,\ \ \widehat{\boldsymbol{RER_t}}\ \right]'$.

- VAR: $x_t = \mathbf{h_x}\, x_{t-1} + u_t$

- **Identification of TOT shocks:**

$$u_t = \Pi \epsilon_t$$
$$\epsilon_t \sim (0, I)$$
$$\Pi_{1,j} = 0 \text{ for } j = 2, \ldots, 6$$

- ToT process is univariate: $h_{x,1,j} = 0$ for $j = 2, \ldots, 6$

(Thus, TOT is exogenous and the first shock is a TOT shock)

- All variables (except tb_t) are log-quadratically detrended.

- Estimate the SVAR country-by-country using OLS.

- Natural extension of the SVAR model of Chapter 7, to include the RER.

Data:

• Include all poor and emerging countries that have at least 30 consecutive annual observations of output, consumption, investment, net exports, the terms of trade, and the real exchange rate in the World Bank's WDI database.

• In all cases the RER is set relative to the US: $RER_t = \frac{\varepsilon_t P_t^{US}}{P_t}$

• Poor and emerging countries are defined as countries with average PPP-converted GDP per capita in U.S. dollars of 2005 over the period 1990 to 2009 below 25,000 dollars.

• 38 countries satisfy both criteria.
Algeria, Argentina, Bolivia, Botswana, Brazil, Burundi, Cameroon, Central African Republic, Colombia, Congo, Dem. Rep., Costa Rica, Cote d'Ivoire, Dominican Republic, Egypt, Arab Rep., El Salvador, Ghana, Guatemala, Honduras, India, Indonesia, Jordan, Kenya, Korea, Rep., Madagascar, Malaysia, Mauritius, Mexico, Morocco, Pakistan, Paraguay, Peru, Philippines, Senegal, South Africa, Sudan, Thailand, Turkey, and Uruguay.

- Sample period: 1980-2011 (32 years).

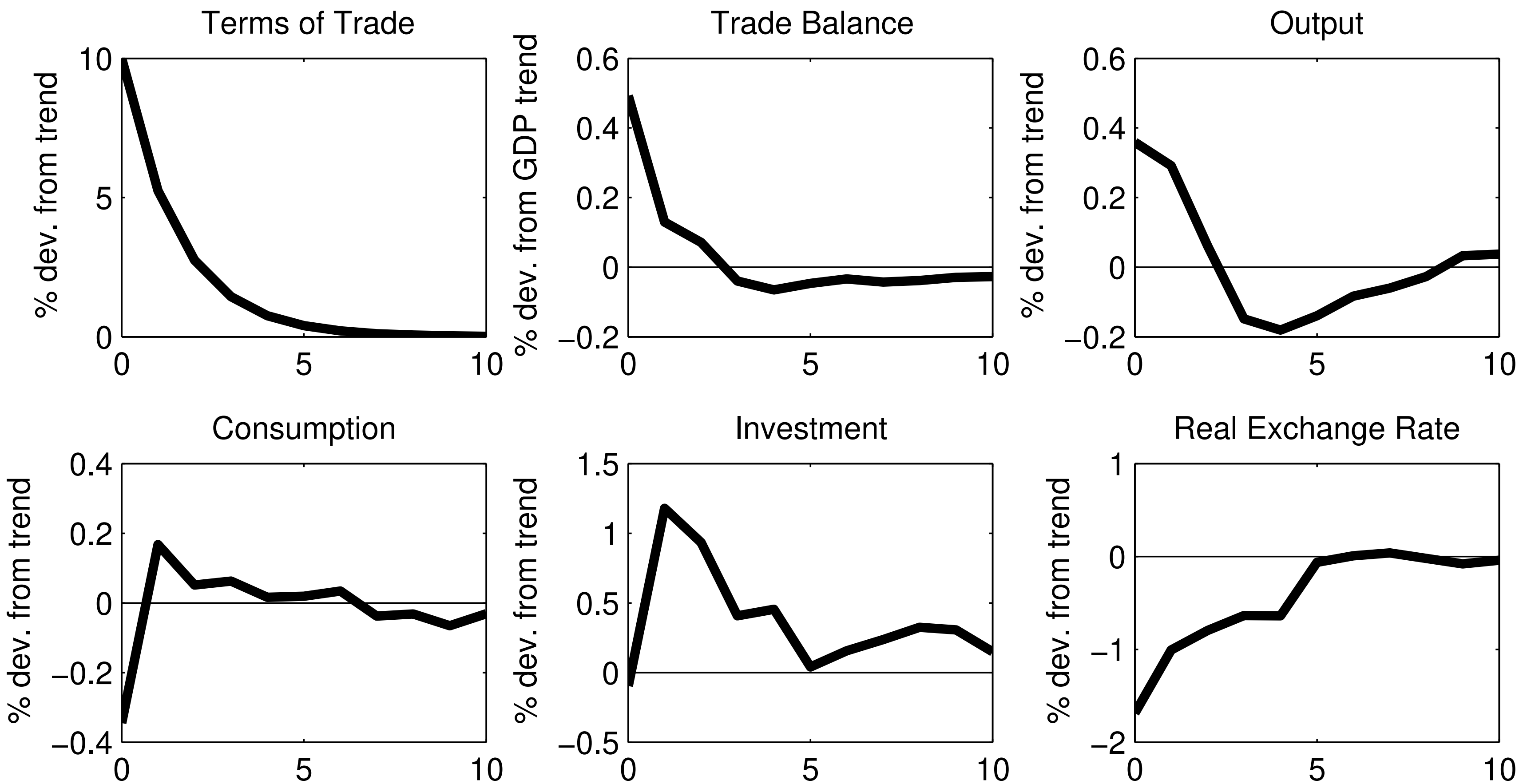
- Our sample of 38 countries.

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

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



Observations on the Estimation Results

• TOT shocks are short lived: half-life of TOT shock is just 1 year.

• R^2 of TOT equations is modest on average, 30 percent

• Trade balance improves (supports Harberger-Metzler-Laursen (HLM) effect).

• TOT improvements are expansionary: On average, a 10% increase in the TOT causes a 0.4% increase n GDP.

• On average, c and i increase, but with a one-year delay. It is puzzling—and indeed an issue worth exploring both empirically and theoretically.

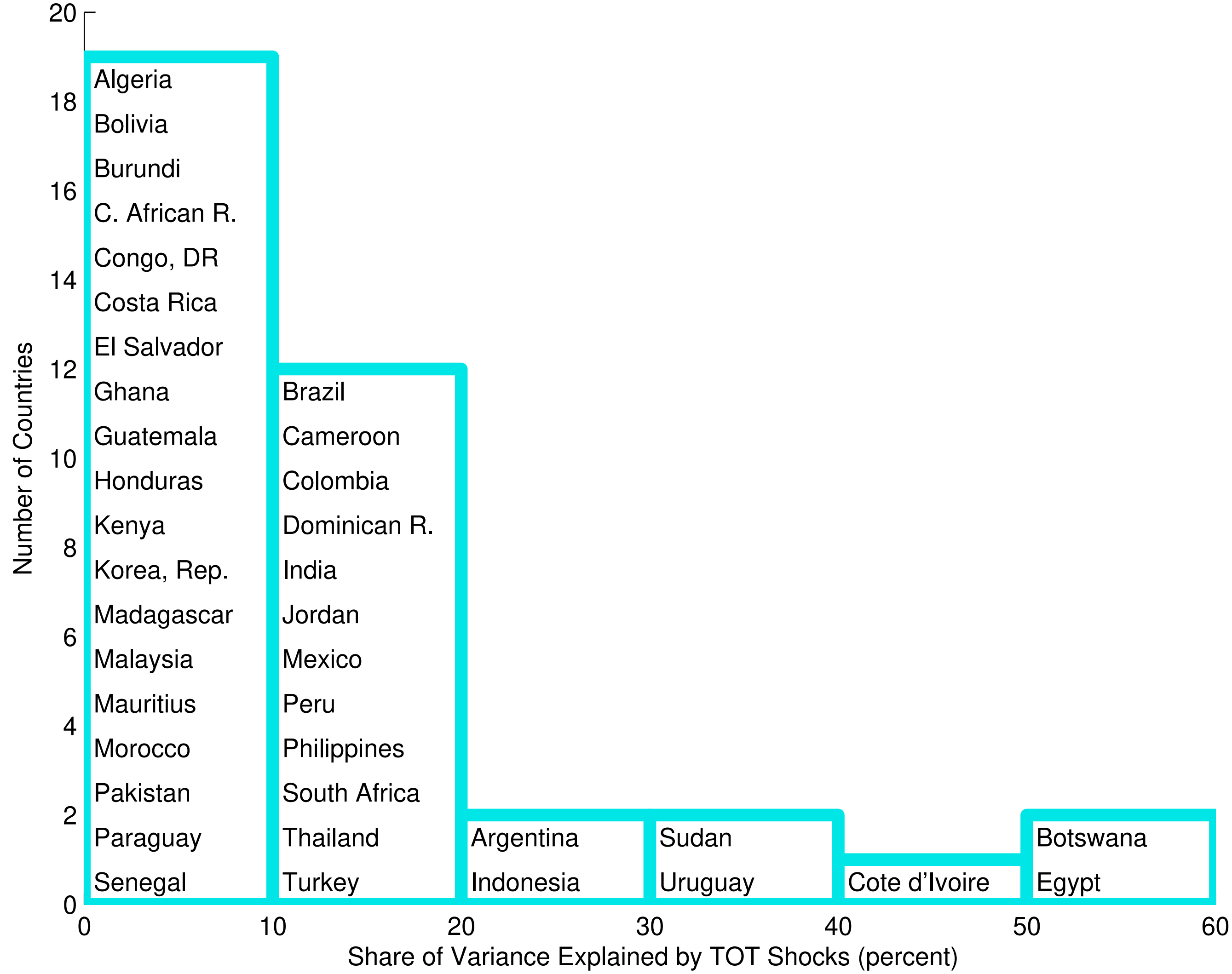
• TOT improvement $\Rightarrow$ RER appreciation ($\downarrow$).

When $tot_t \uparrow \Rightarrow$ home becomes more expensive vis-à-vis the rest of the world. Thus the SVAR model lends support to the predictions of the TNT model.

Share of Variance Explained by Terms of Trade Shocks: SVAR Evidence

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

Country-Level Shares of Variance of Output Explained by Terms of Trade Shocks



Summary of Variance Decomposition

• On average, TOT shocks explain 10 percent of the variance of output in poor and emerging countries.

• In only 5 countries (Botswana, Egypt, Cote d'Ivoire, Sudan, and Uruguay) TOT shocks explain more than 30 percent of the variance of output.

• SVAR evidence is at odds with conventional wisdom that TOT shocks account for a large share of output variability in poor and emerging markets.

The MXN Model

Elements of the MXN Model

- Extension of MX model to include **non-tradable goods** (and sector).
- Small open economy that takes terms of trade as given.
- 3 production sectors: exportable goods, importable goods, nontradable goods.
- All goods are produced and consumed (difference with the TNT model).
- All goods are produced using capital and labor.
- Sector specificity of capital and labor.

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

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

and to the laws of motion for physical capital

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

Notation: c_t consumption; $h_t^i, k_t^i, i_t^i, w_t^i, u_t^i$ hours, capital, investment, wages, rental rates of capital in sector $i = m, x, n$ (importable, exportable, and non-tradable sector); d_t debt due in t; p_t^τ relative price of tradables.

All terms in the budget constraint are expressed in units of final goods.

$\delta \in (0, 1)$ is the depreciaiton rate of capital. Functions $\Phi_j(x) = \frac{\phi_j}{2}x^2;\ j = m, x, n$ introduce capital adjustment costs.

Firms Producing Final Goods

$$\max_{a_t^T, a_t^n} \left\{ a_t - p_t^T a_t^T - p_t^n a_t^n \right\}$$

subject to

$$a_t = \left[\chi_T \left(a_t^T \right)^{1-\frac{1}{\mu_{Tn}}} + (1-\chi_T) \left(a_t^n \right)^{1-\frac{1}{\mu_{Tn}}} \right]^{\frac{1}{1-\frac{1}{\mu_{Tn}}}},$$

Notation:

a_t = domestic absorption of final goods a.

a_t^T = domestic absorption of a composite of traded goods.

a_t^n = (domestic) absorption of nontraded goods.

μ_{Tn} = elasticity of substitution between T and N goods.

χ_T = expenditure share on tradables if μ_{Tn}.

Production of the Tradable Composite Good

Firms producing tradable goods solve the problem

$$\max_{a_t^m, a_t^x} \{p_t^\tau a_t^\tau - p_t^m a_t^m - p_t^x a_t^x\}$$

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

Notation:
$a_t^\tau =$ 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 $\mu_{mx} = 1$.
$p_t^m =$ relative price of importable goods.
$p_t^x =$ relative price of exportable goods.

Production of Importable Goods

Productive sector 1

Firms producing importable goods solve the problem

$$\max_{h_t^m, k_t^x} \left\{ p_t^m y_t^m - w_t^m h_t^m - u_t^m k_t^m \right\}$$

subject to the production technology

$$y_t^m = A^m \left(k^m\right)^{\alpha_m} \left(h^m\right)^{1-\alpha_m}$$

Notation:
y_t^m = quantity of importable goods produced domestically.
A^m = level of productivity in the importable sector.
k_t^m = capital input in the importable sector.
h_t^m = labor input in the importable sector.
w_t^m = wage rate in the importable sector.
u_t^m = rental rate of capital in the importable sector.
$1 - \alpha_m$ = labor share in the importable sector.

Production of Exportable Goods

Productive sector 2

Firms producing exportable goods solve the problem

$$\max\{p_t^x y_t^x - w_t^x h_t^x - u_t^x k_t^x\}$$

subject to the production technology

$$y_t^x = A^x \left(k^x\right)^{\alpha_x} \left(h^x\right)^{1-\alpha_x}$$

Notation:
y_t^x = quantity of exportable goods produced.
A^x = level of productivity in the exportable sector.
k_t^x = capital input in the exportable sector.
h_t^x = labor input in the exportable sector.
w_t^x = wage rate in the exportable sector.
u_t^x = rental rate of capital in the exportable sector.
$1-\alpha_x$ = labor share in the exportable sector.

Production of Nontradable Goods

Productive sector 3

Firms producing nontradable goods solve the problem

$$\max\{p_t^n y_t^n - w_t^n h_t^n - u_t^n k_t^n\}$$

subject to the production technology

$$y_t^n = A^n \left(k^n\right)^{\alpha_n} \left(h^n\right)^{1-\alpha_n}$$

$y_t^n =$ quantity of nontraded goods produced.
$A^n =$ level of productivity in the nontradable sector.
$k_t^n =$ capital input in the nontradable sector.
$h_t^n =$ labor input in the nontradable sector.
$w_t^n =$ wage rate in the nontradable sector.
$u_t^n =$ rental rate of capital in the nontradable sector.
$1 - \alpha_n =$ labor share in the nontraded sector.

Imports and Exports in the model

Market clearing goes in a similar fashion as in the MX model. In that case, absorption is related to imports (exports) and output as

$$m_t = p_t^m (a_t^m - y_t^m)$$

$$x_t = p_t^x (y_t^x - a_t^x)$$

Debt Elastic Interest-Rate Premium

To ensure a stationary equilibrium process for external debt, we assume that the country interest-rate premium is debt elastic,

$$r_t = r^* + p(d_{t+1})$$

where $p(\cdot)$ is assumed to be increasing taking the form

$$p(d) = \psi \left(e^{d-\bar{d}} - 1 \right)$$

The Terms of Trade Process

As in the empirical SVAR analysis, we assume that the terms of trade follow a univariate first-order autoregressive (AR(1)) process of the form

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

where $\overline{tot} > 0$ is the deterministic level of the terms of trade.
$\rho \in (-1,1)$ is the serial correlation.
$\sigma_{tot} > 0$ is the standard deviation of the innovation to the terms of trade.

Calibrated and Estimated 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	$\overline{d}$	A^x	β				
$*$	$*$	$*$	$*$	0.8980	0.4360	0.0078	1	0.9009				

Notes.

*Country-specific estimates.

$\frac{\sigma_i}{\sigma_y}$ and $\frac{\sigma_{tb}}{\sigma_y}$ are conditional on tot shocks

$s_n \equiv p^n y^n / y$,

$s_x \equiv x/y$,

$s_{tb} \equiv (x-m)/y$, where $y \equiv p^m y^m + p^x y^x + p^n y^n$.

Key parameters determining the importance of terms of trade shocks:

• ρ and σ_{tot}, the more volatile and the more persistent are terms of trade shocks, the more volatile is output.

• The size of the nontraded sector: $\frac{p^n y^n}{y}(= 50\%)$. The larger the nontraded sector, the smaller the output effects of tot shocks.

• The steady-state trade share: $\frac{x+m}{y}(= 39\%)$. The larger the trade share, the larger the output effects of tot shocks.

Estimate capital adjustment cost parameters and the debt elasticity of the interest rate, ϕ_m, ϕ_x, ϕ_n, ψ, χ_m, to match country-by-country the relative standard deviations

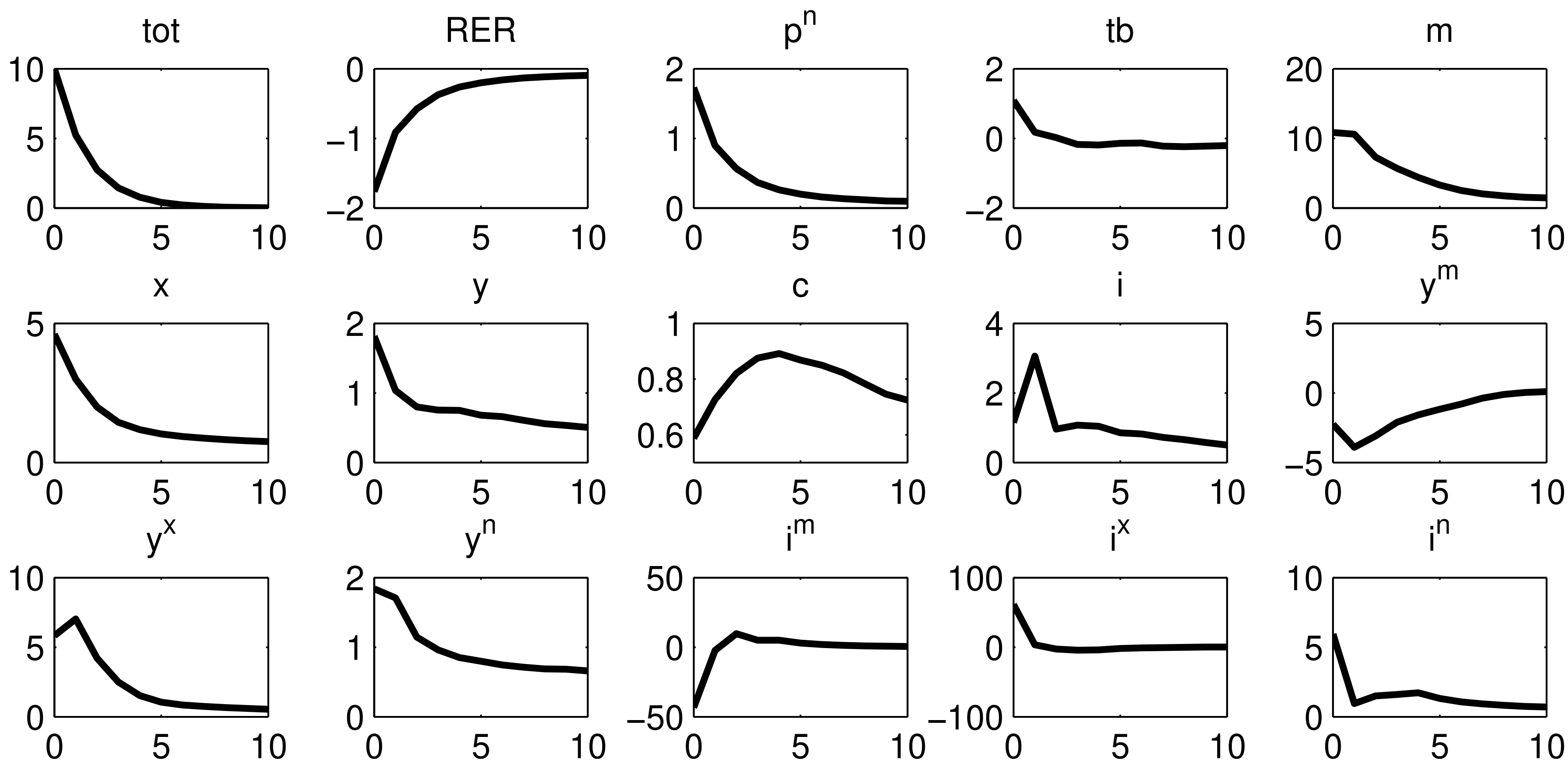
$$\sigma_i/\sigma_y \quad \text{and } \sigma_{tb}/\sigma_y$$

conditional on terms of trade shocks and $\sigma_{i_x+i_m}/\sigma_{i_n} = 1.5$.

Medians of Country-Specific Estimates of the Capital Adjustment Cost Parameters and the Debt Elasticity of the Interest Rate

					σ_i/σ_y		σ_{tb}/σ_y	
	ϕ_m	ϕ_x	ϕ_n	ψ	Data	Model	Data	Model
Median	1.13	1.40	0.69	0.84	3.36	3.00	0.64	0.74
MAD	1.13	1.40	0.69	0.77	1.42	0.52	0.33	0.34

Median of Country-Specific Impulse Response to a Ten-Percent Terms-of-Trade Shock Predicted by the MXN Model



Observations on Impulse Responses to a TOT Shock Implied by MXN Model

- **Substitution effect of an increase in tot_t on supply side:** Firms produce more exportables and less importables, and, given p_t^n, would produce less nontradables.

- **Substitution effect of an increase in tot_t on demand side:** Demand for importable goods and nontraded goods rises, domestic demand for exportable goods falls. TOT ($\uparrow$) $\Rightarrow$ wealth effect $\rightarrow$ demand for all goods $\uparrow$.

- Price of nontradables, p_t^n, rises and the real exchange rate appreciates.

- Both exports and imports increase. Positive Net effect on trade balance. Model impulse response is consistent with HLM effect.

- Aggregate investment increases by less than 10% on impact. But investment in the exportable sector rises by 61% while it decreases by over 40% in the importable sector.

Comparison of SVAR and MXN Model

Proper comparison of empirical and theoretical models requires measuring macroeconomic indicators (y_t, c_t, i_t, tb_t) in the same units.

To this end, we construct the theoretical counterpart to the observable variable 'GDP at constant LCU' used in the SVAR analysis. This requires deflating nominal variables by a Paasche GDP deflator index. This yields

$$y_t^{\text{constant prices}} = p_{ss}^x y_t^x + p_{ss}^m y_t^m + p_{ss}^n y_t^n,$$

Similarly, to obtain total consumption expenditure at constant prices, we must divide c_t by the factor $\frac{p_t^x y_t^x + p_t^m y_t^m + p_t^n y_t^n}{p_{ss}^x y_t^x + p_{ss}^m y_t^m + p_{ss}^n y_t^n}$, which yields

$$c_t^{\text{constant prices}} = c_t \frac{p_{ss}^x y_t^x + p_{ss}^m y_t^m + p_{ss}^n y_t^n}{p_t^x y_t^x + p_t^m y_t^m + p_t^n y_t^n}$$

Similar expressions obtain for the observable versions of i_t and tb_t.

Share of Variances of Output and Other Indicators Explained by Terms-of-Trade Shocks According to the MXN Model

To compute % of variance of output explained by TOT shocks in MXN model:

(1) With tot_t as the sole driving process, compute the variance of output predicted by the MXN model.

(2) Divide this value obtained in (1) by the observed unconditional variance of output predicted by the SVAR model (i.e., the variance of output when all shocks in the SVAR are active).

We do the same with the other macroeconomic indicators of interest (consumption, investment, the trade balance, and the real exchange rate).

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.

Finding:

• Median share of the variance of output explained by TOT shocks in MXN model is close to the one predicted by the SVAR model (13 vs. 10 percent).

• Both the MXN and SVAR models concur in that, contrary to the conventional wisdom, TOT shocks are not a major driver of the business cycle.

• This result extends to the other macroeconomic indicators included in the SVAR, although the MXN model overestimates the role of TOT shocks for the trade balance and consumption and underestimates it for the RER.

The Importance of Measuring Variables Consistently in the SVAR and MXN Models

One possible reason for the discrepancy between our findings of a small role for TOT shocks as drivers of the business cycle and the conventional view is measurement.

Suppose that in computing the predictions of the MXN model for the importance of TOT shocks, we had measured output in units of current consumption ($p_t^x y_t^x + p_t^m y_t^m + p_t^n y_t^n$)—a common practice—instead of at constant prices using a Paasche price deflator ($p_{ss}^x y_t^x + p_{ss}^m y_t^m + p_{ss}^n y_t^n$).

Let x_t^{CPI} denote variable x_t measured in **units of consumption.**
Let x_t^{YPI} denote variable x_t measured in **units of output**.

Ratio of Variances Predicted by Theoretical Model

	y	c	i
$\frac{\text{var}(x_t^{CPI})}{\text{var}(x_t^{YPI})}$	2.4	1.7	1.2

• Predicted variances due to ToT shocks of output, consumption, and investment are **larger** when these aggregates are expressed in units of consumption goods as opposed to units of output.

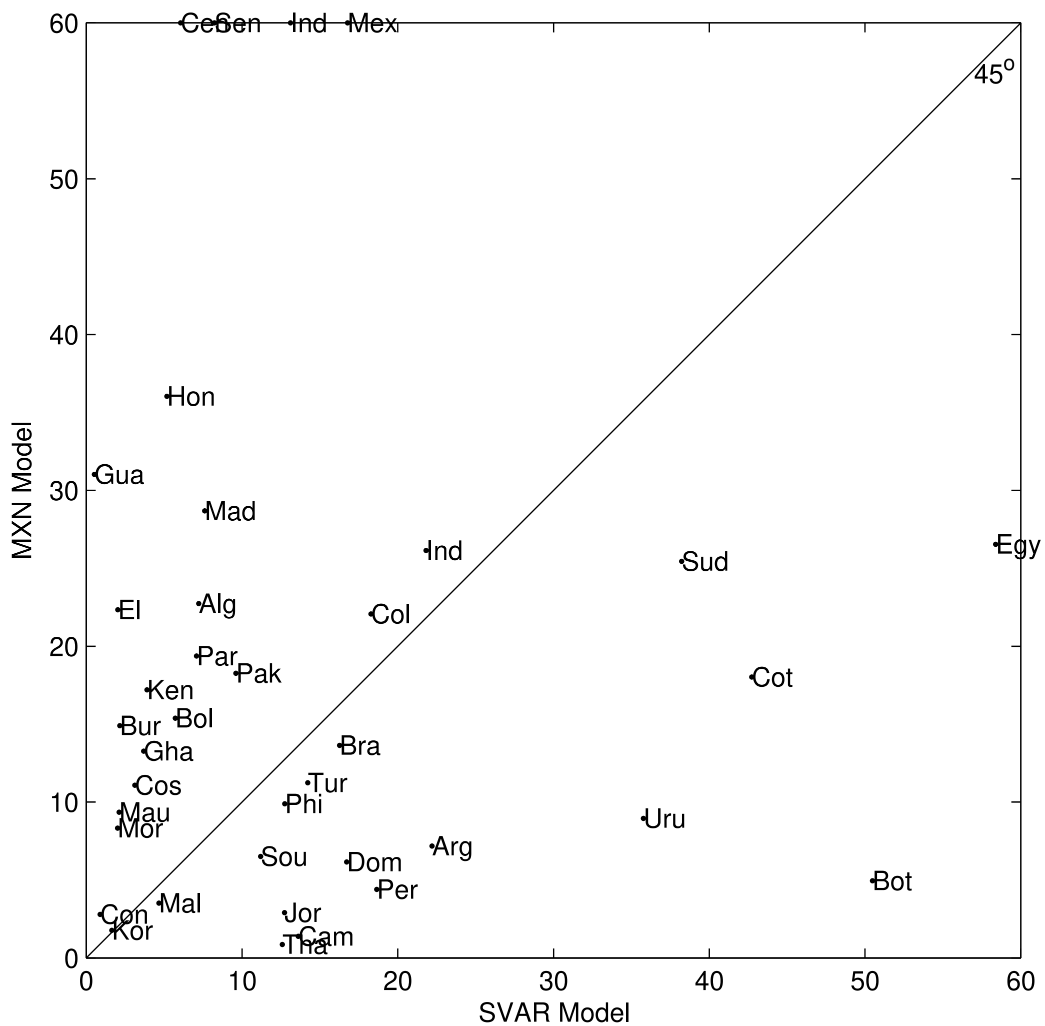
The Terms-of-Trade Disconnect

The table in slide slide 44 conveys the impression that the MXN and SVAR model speak with the same voice with respect to the importance of terms-of-trade shocks for aggregate movements in output.

This is certainly the case on average across the 38 countries in the panel. However, the picture that emerges when one looks at the predictions of the MXN and SVAR models at the country level is quite different.

This is the point of the graphs on the next slide.

Evaluating The Conventional Wisdom
How Does the Model Fit Country-Level Data?



Observations on the Figure

• If MXN model were to fit the data well, all circles in the figure would line up close to the 45-degree line.

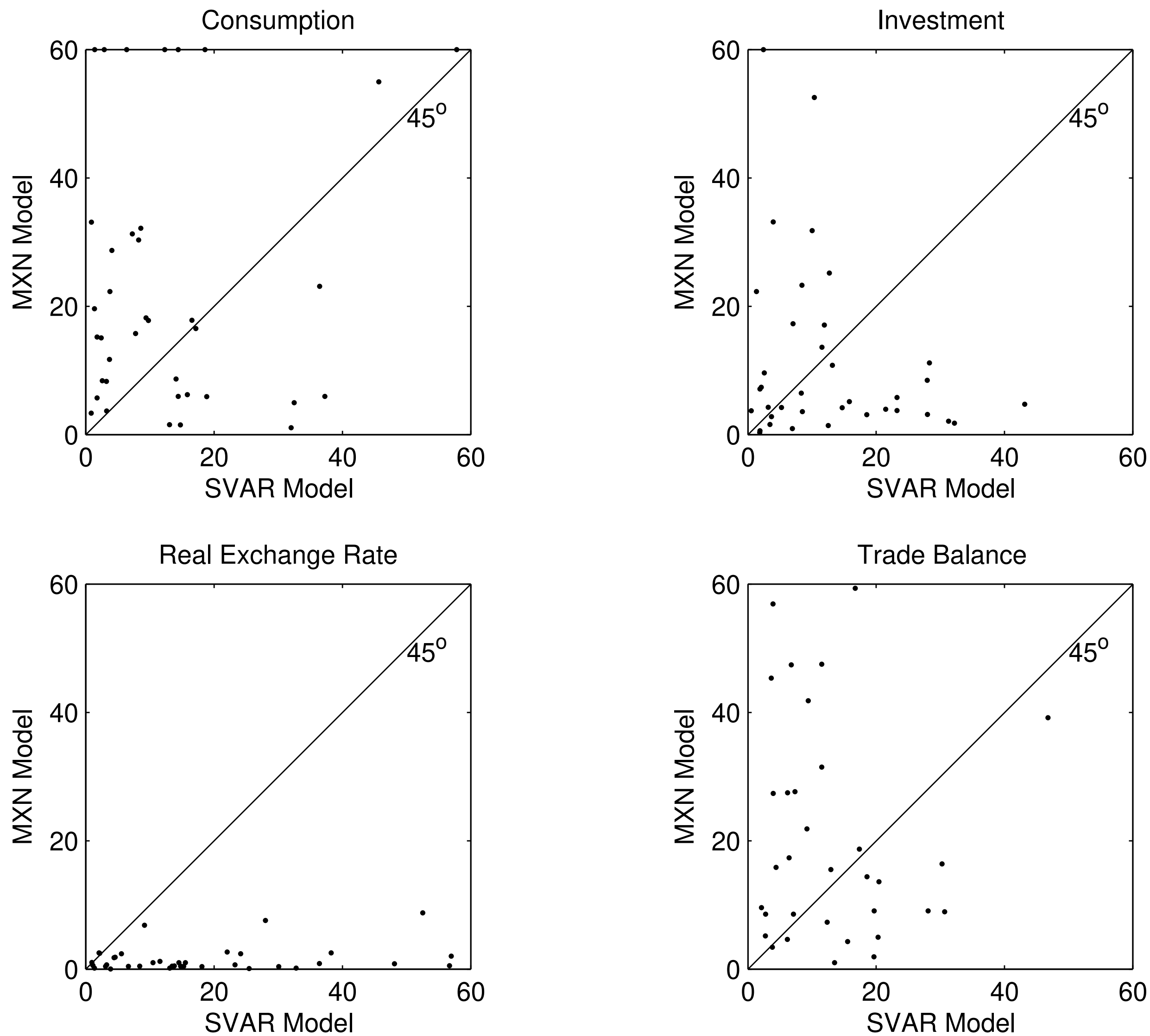
• The cloud of circles, however, displays no discernible pattern.

• Although the predictions of the MXN model are in line with the SVAR model on average across countries, the match is quite poor at the individual level.

• This result extends to the other macroeconomic indicators included in the SVAR model, as the figure in the next slides shows.

Variance of Consumption, Investment, the Trade Balance, and the Real Exchange Rate

Explained By Terms-of-Trade Shocks: SVAR Versus Model



Conclusions: Empirical Analysis

1. Conventional wisdom: TOT shocks represent a major source of fluctuations for emerging countries. However, a SVAR analysis suggests otherwise.

3. Does this mean world prices are not important transmitters of aggregate disturbances? No.

Perhaps TOT shocks, being a highly aggregated summary of world prices, might be a poor way of capturing how external shocks transmit.

4. Typical country trades internationally in a large number of goods. Thus, world shocks are likely to transmit through a large number of world prices.

A single summary statistic, may not capture all of the domestic effect of external disturbances.

5. The above observations suggest using more disaggregated world price data.

Fernández, Schmitt-Grohé, and Uribe (JIE, 2017) follow this route: Variation of the SVAR model studied here in which the terms of trade is replaced by 3 world commodity prices. Finding: jointly, these prices explain about 30 percent of aggregate fluctuations in emerging and poor countries.

Conclusions: Theoretical Analysis

1. The theoretical framework on which the conventional wisdom is based, a multi-sector, open economy version of the RBC model, which we called the **MXN model, captures well the transmission mechanism of TOT shocks on average, but does a poor job at the country level**.

2. One **promising avenue is to expand the MXN model to allow for multiple importable and exportable goods** (as opposed to just one importable and one exportable good). In this setting, just as in the empirical analysis, the terms of trade will not suffice to capture the whole mechanism through which world shocks transmit to the domestic economy.

3. An **important byproduct of the theoretical analysis is the need to be careful about measuring variables in the same units in the theoretical and the empirical models**. Failing to do so can lead to spurious differences between the predictions of the theoretical model and the data.