

Sudden Stops, Sectoral Reallocations, and Real Exchange Rates

Timothy J. Kehoe

University of Minnesota and Federal Reserve Bank of Minneapolis

and

Kim J. Ruhl

University of Texas, Austin

Definition: sudden stops

An abrupt decline in capital inflows.

- Argentina, Mexico: 1994
- Indonesia Korea, Thailand: 1996-98
- Germany, Sweden, Spain: 1992-93

It is not speed that kills, it is the sudden stop.

— Bankers' Adage (Dornbusch et al. 1995)

Two lines of research

What causes sudden stops?

- large literature
- take effects – loss of output – as given

What are the effects of sudden stops? (our approach)

- fewer studies
- one sector models
- take sudden stop as given

Effects of sudden stops

Aggregate

- real exchange rate depreciation
- trade balance surplus
- decrease in GDP
- decrease in TFP

Sectoral Detail

- tradable good output falls less than nontradable
- labor reallocated to tradable good sector
- increase in p^T / p^N

Example: Mexico 1994-95

Opens to capital flows: late 1980s

- trade deficits
- real exchange rate appreciation

Sudden stop: 1994-95

- trade surplus
- real exchange rate depreciation
- fall in GDP, TFP

End of sudden stop

- trade deficits
- real exchange rate appreciation
- recovery of GDP, TFP

Our model

Small open economy

- multisector: tradable, nontradable
- costly to adjust labor across sectors

Sudden stop

- tradable goods price increase, increase production
- capital and labor misallocated
- costs from moving labor

Model accounts for:

- real exchange rate
- labor allocation
- trade balance

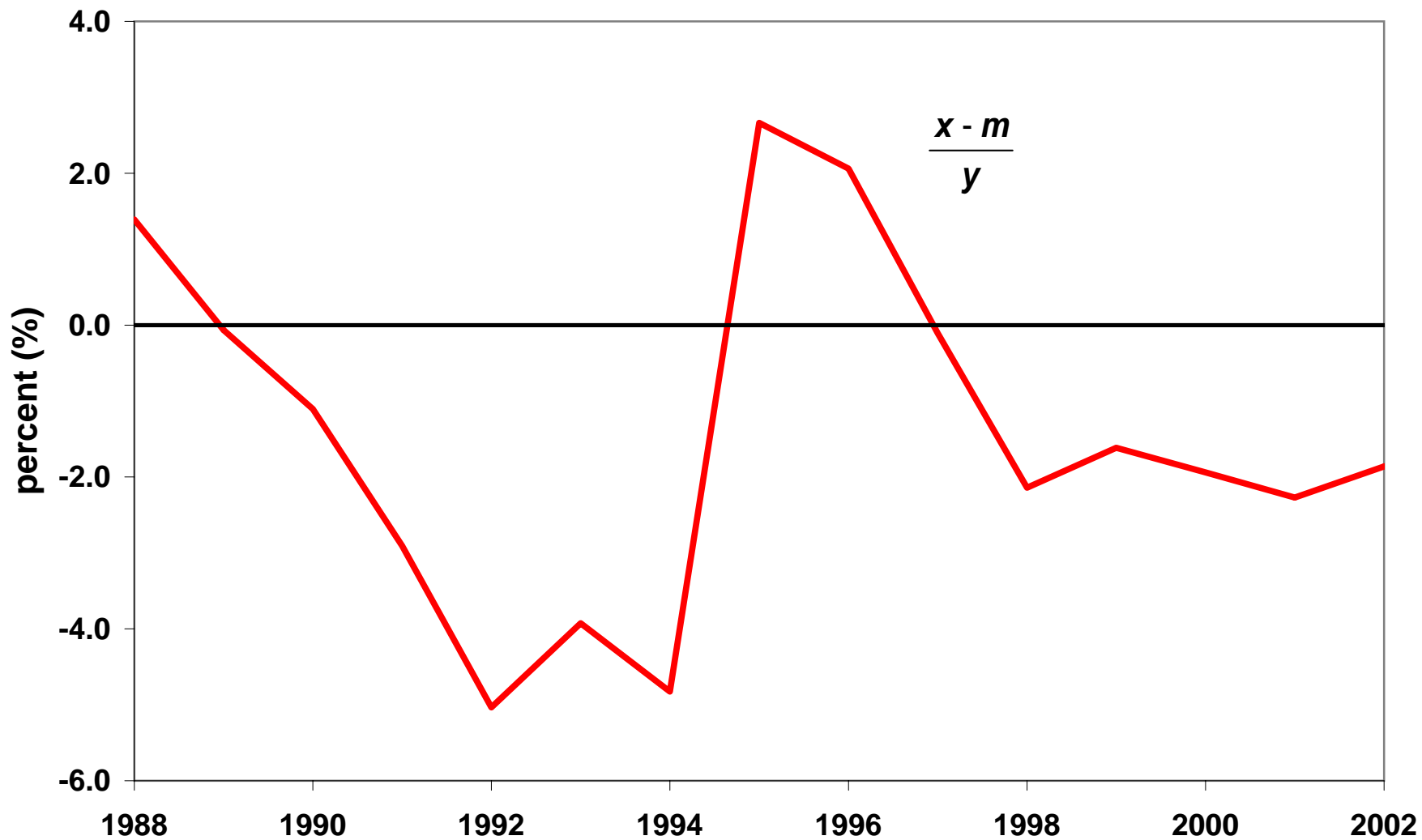
Misses:

- GDP, TFP

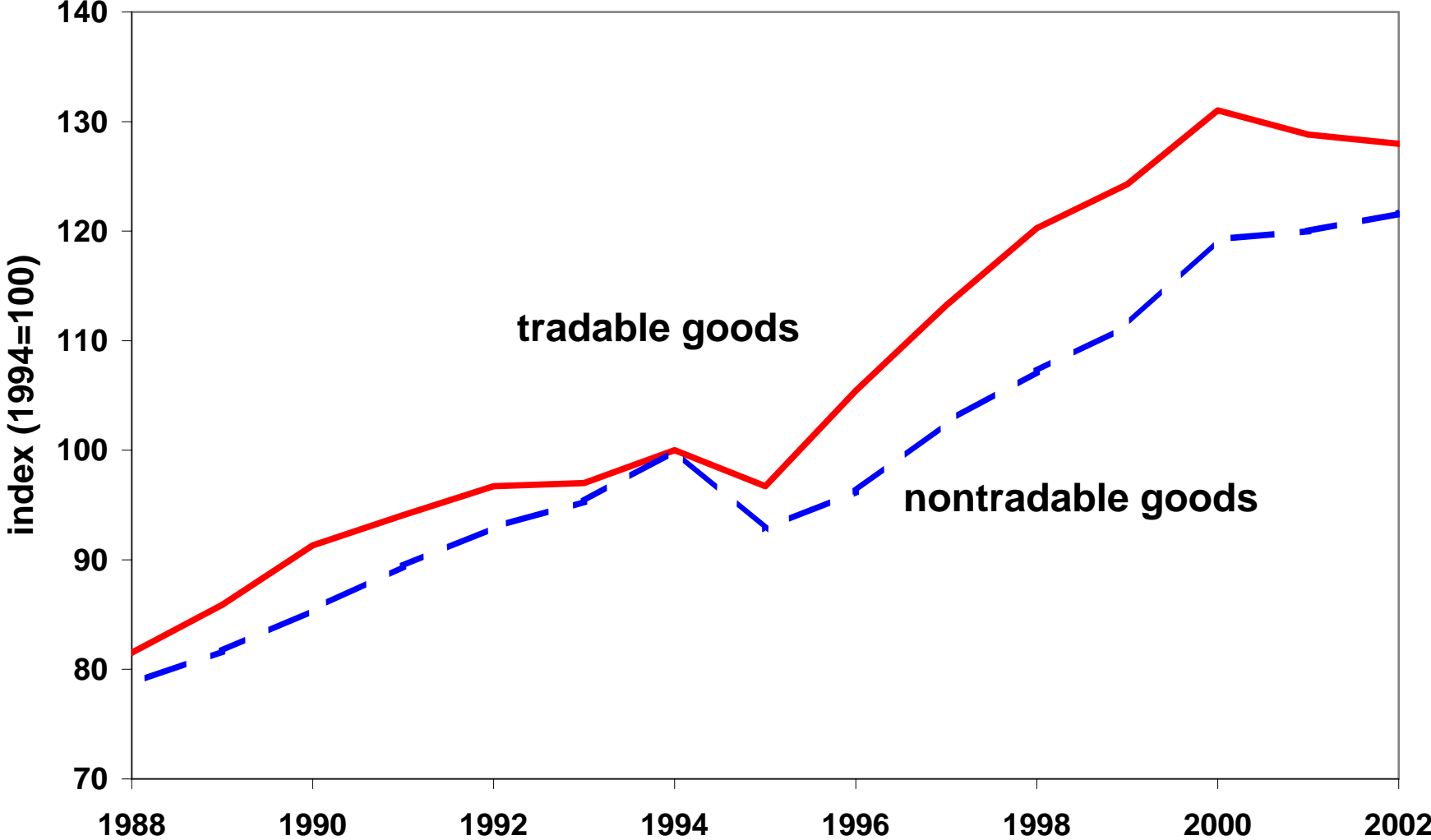
Outline

1. Data: Mexico
2. Explanations
3. Model
4. Calibration
5. Results

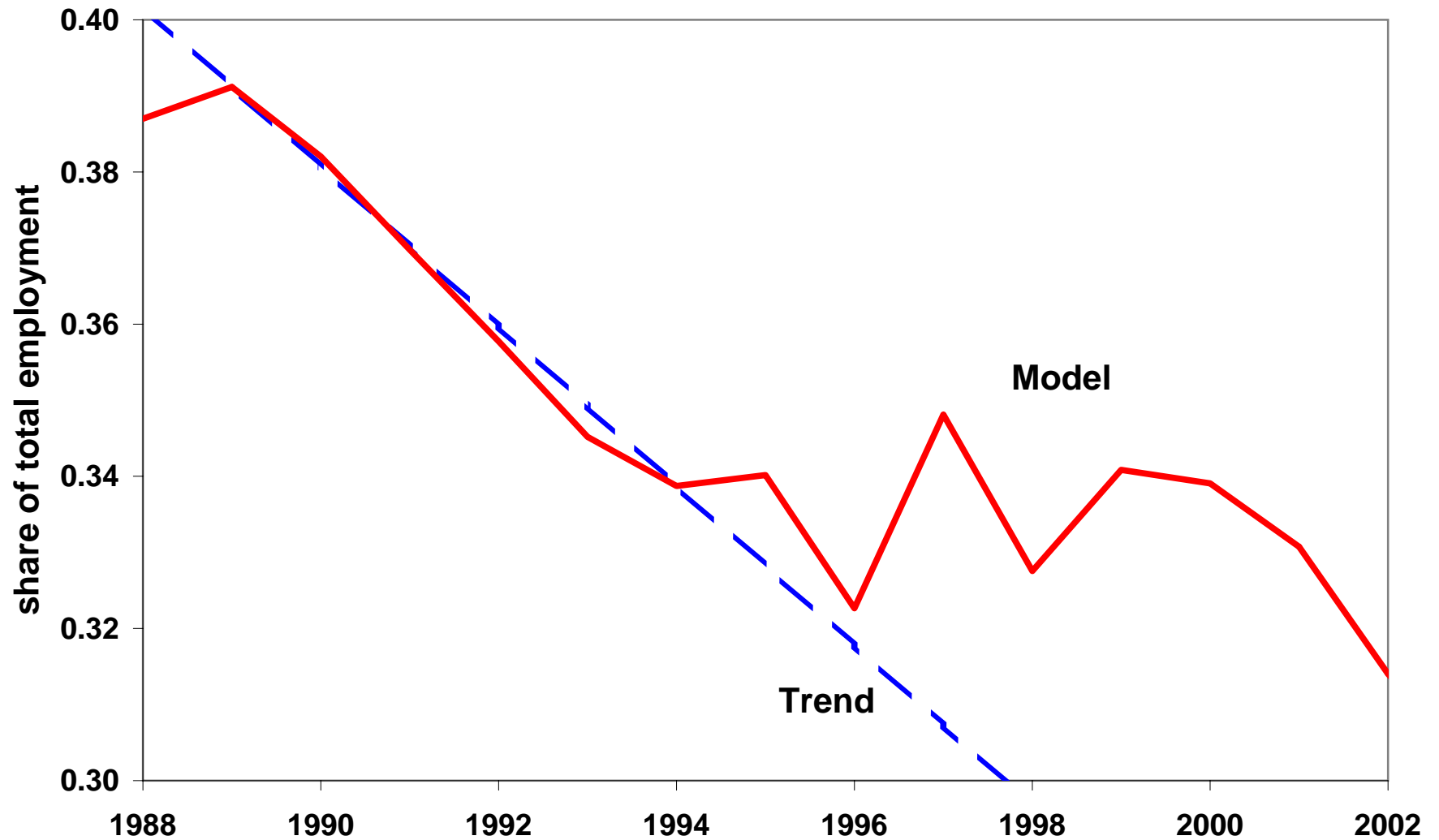
Mexico: trade balance



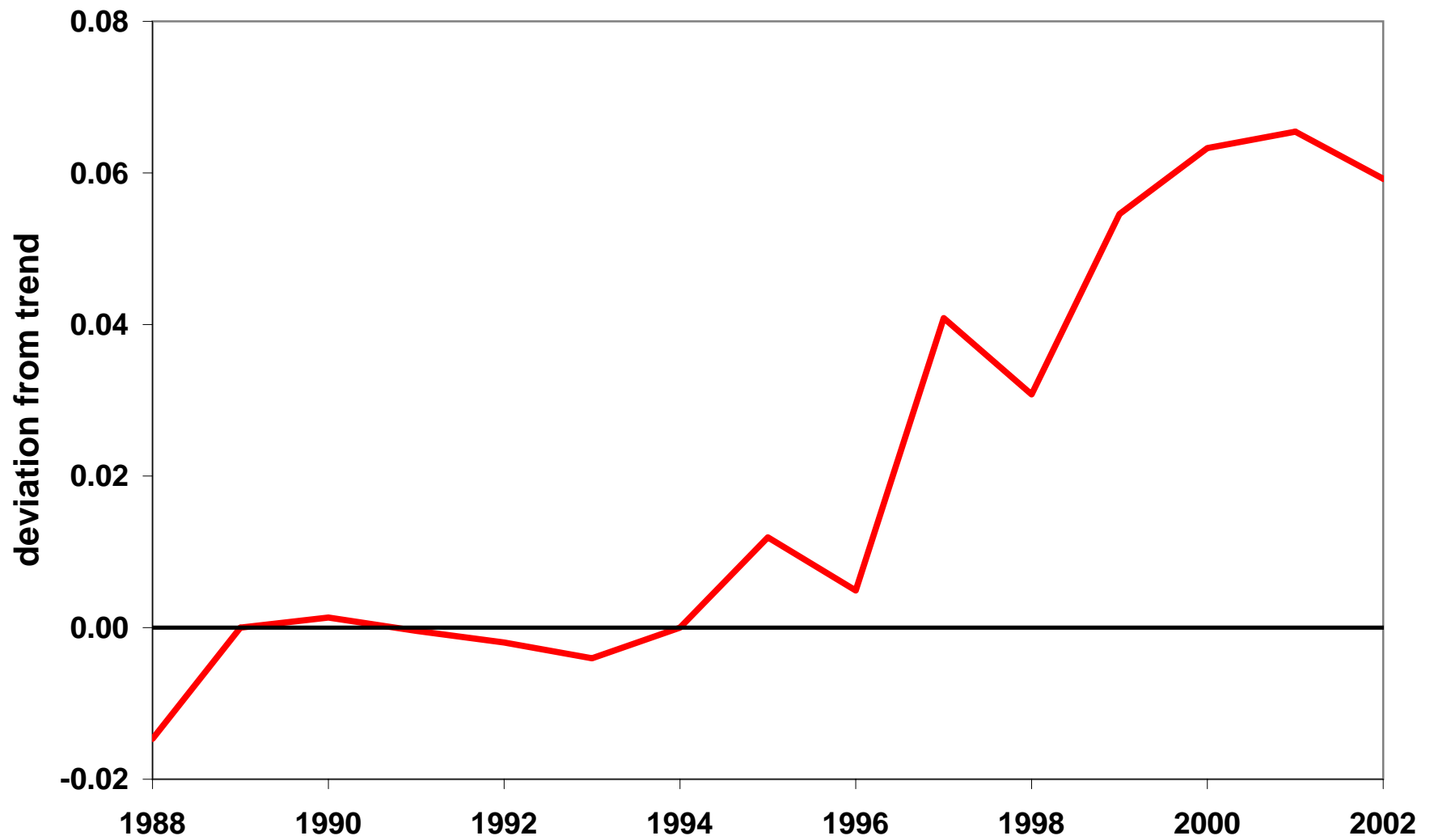
Mexico: value added by sector



Mexico: traded good employment



Mexico: traded good employment, detrended



Mexico-U.S. real exchange rate

$$RER_{mex,us} = NER_{mex,us} \frac{P_{us}}{P_{mex}}$$

- $NER_{mex,us}$: nominal exchange rate — pesos per dollar
- P_j : GDP price deflator in country

Decomposing real exchange rates

$$RER_{mex,us} = \left(NER_{mex,us} \frac{P_{us}^T}{P_{mex}^T} \right) \left(\frac{P_{mex}^T}{P_{mex}} / \frac{P_{us}^T}{P_{us}} \right) = RER_{mex,us}^T \times RER_{mex,us}^N$$

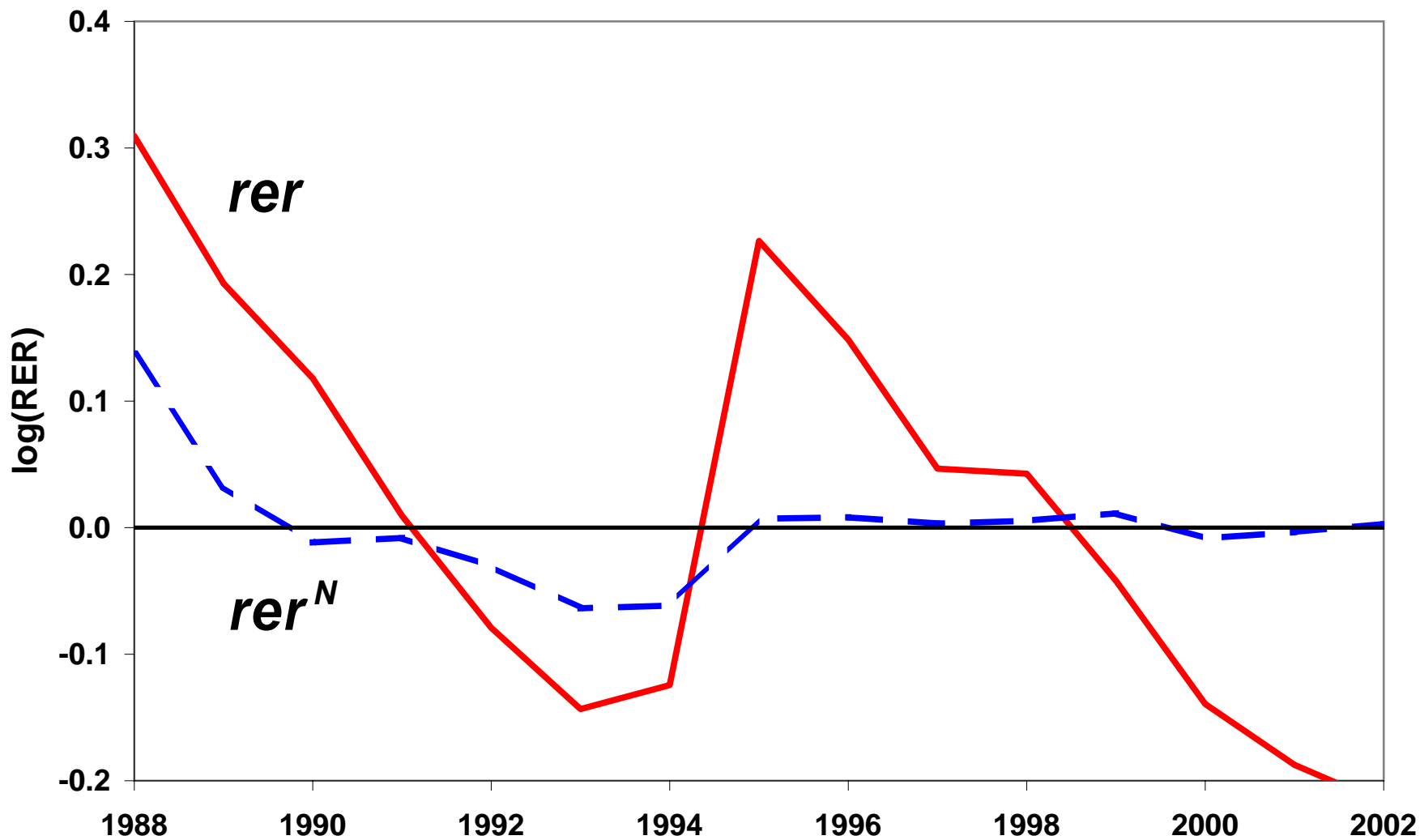
Deviations from the law of one price:

$$RER_{mex,us}^T = NER_{mex,us} \frac{P_{us}^T}{P_{mex}^T}$$

Relative price of nontradable to tradable goods:

$$RER_{mex,us}^N = \left(\frac{P_{mex}^T}{P_{mex}} \right) / \left(\frac{P_{us}^T}{P_{us}} \right)$$

Mexico-U.S. real exchange rate



Growth accounting

Y_t : real GDP (national income accounts)

X_t : real investment (national income accounts)

L_t : hours worked (labor surveys)

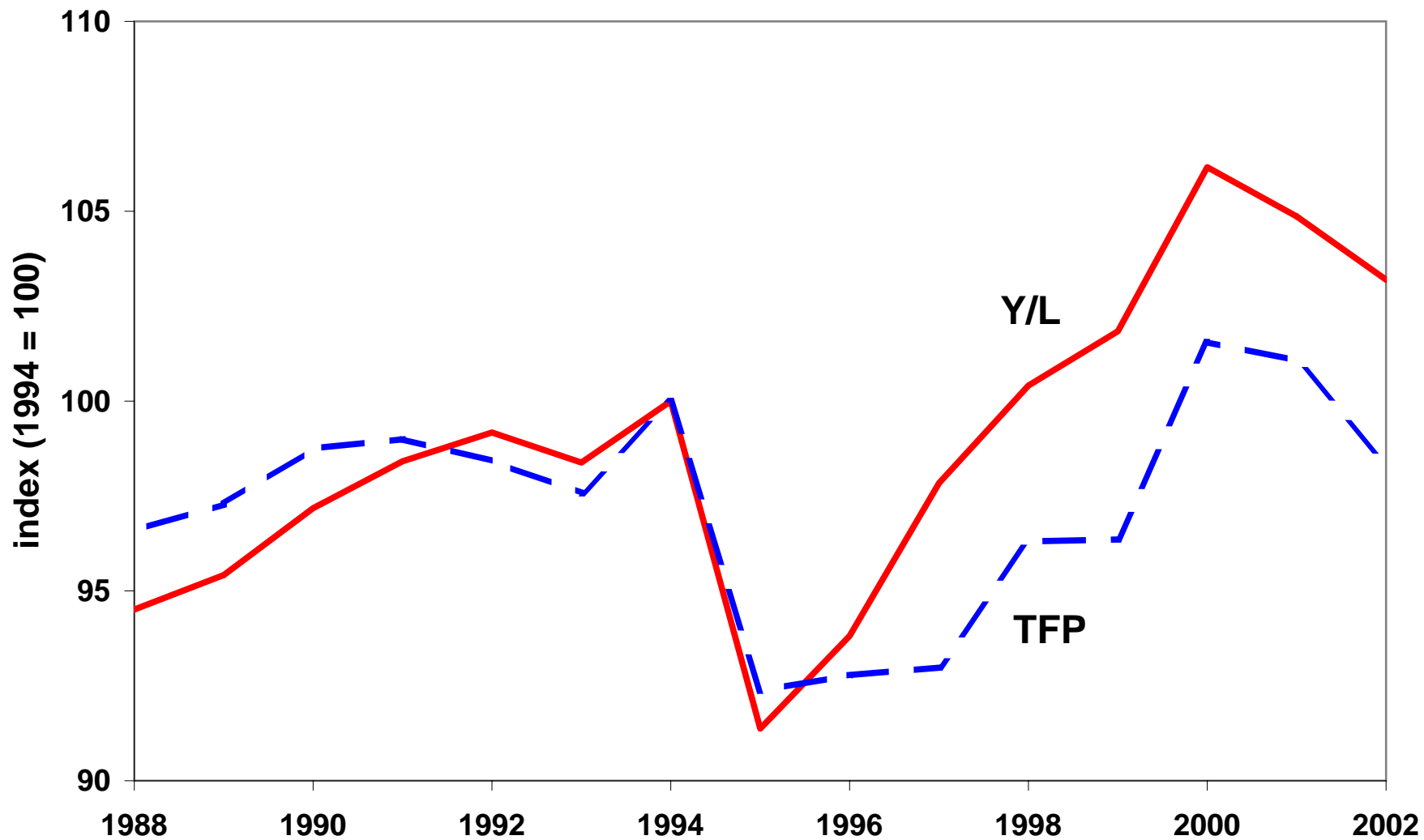
Construct Capital Stocks:

$$K_{t+1} = (1 - \delta) K_t + X_t$$

Total factor productivity:

$$A_t = Y_t / K_t^\alpha L_t^{1-\alpha}$$

Mexico: output and TFP



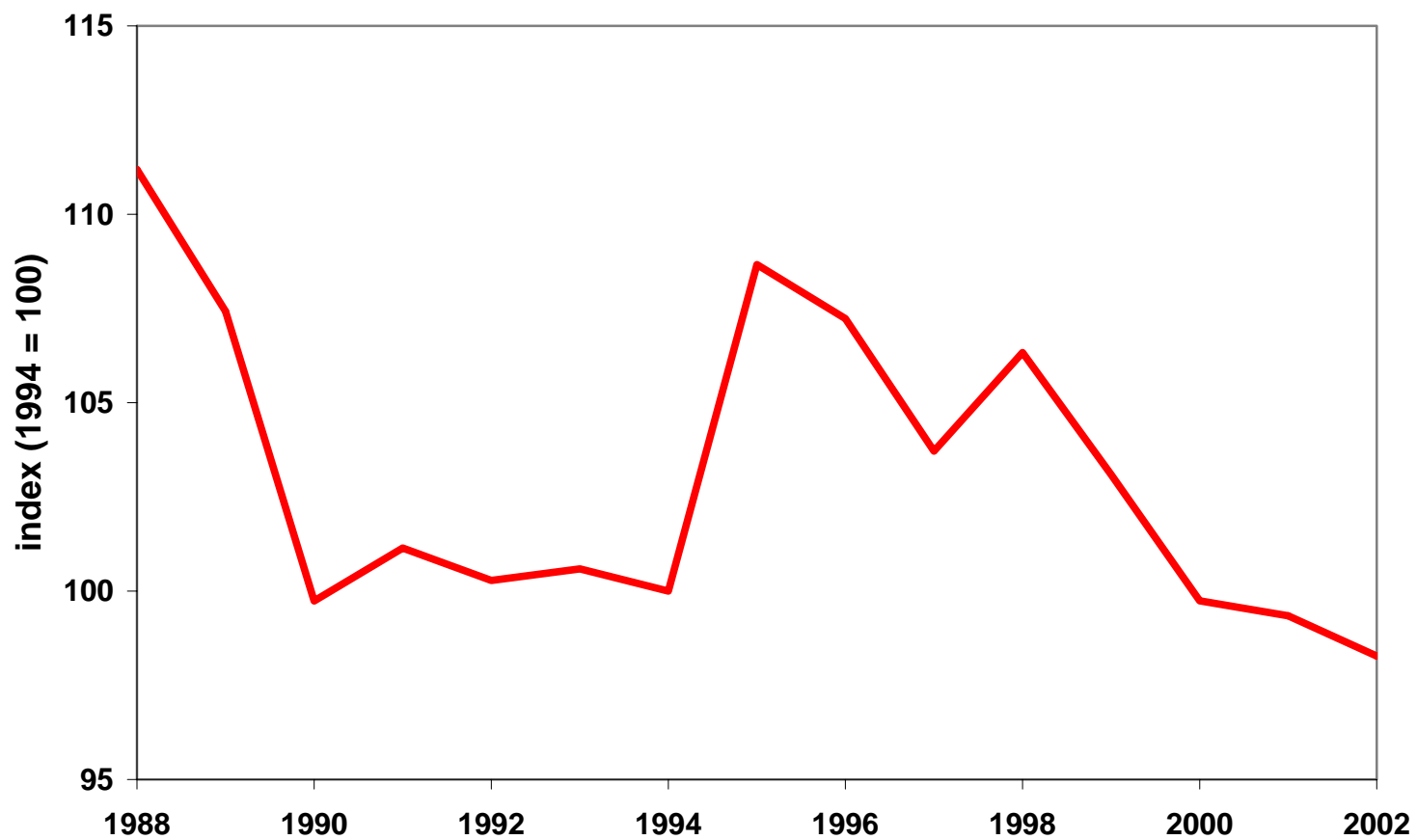
Two theories

Output and TFP fall with a sudden stop because:

1. cost of imported intermediates increases
2. economy has real frictions that waste output and inputs

1. Cost of imported intermediates increases

Mexico: terms of trade



1. Cost of imported intermediates increases

A deterioration in the terms of trade makes it expensive for an economy to import intermediate goods.

International trade as production technology

- Exports are inputs, imports are outputs.
- decline in terms of trade \approx negative technology shock.

Can this negative “technology shock” account for the drop in TFP during the crisis?

1. Cost of imported intermediates increases

A deterioration in the terms of trade makes it expensive for an economy to import intermediate goods.

International trade as production technology

- Exports are inputs, imports are outputs.
- decline in terms of trade \approx negative technology shock.

Can this negative “technology shock” account for the drop in TFP during the crisis?

No.

Standard national income accounting (SNA, NIPA) implies that terms of trade shocks have no first-order effects on real output (GDP, GNP)

A simple model with intermediate goods

Labor

$$\ell = \bar{\ell}$$

Final good

$$y = f(\ell, m)$$

Intermediate good

$$m = \frac{x}{a}$$

Feasibility

$$c + x = y$$

Real GDP (expenditure, output)

$$c = y - x = (f(\ell, m) + p_0 m) - (p_0 m + x) = f(\ell, m) - x$$

Competitive economy solves

$$\max_m f(\bar{\ell}, m) - am$$

$$f_m(\bar{\ell}, m(a)) \equiv a$$

$$f_{mm}(\bar{\ell}, m(a))m'(a) = 1$$

$$m'(a) = \frac{1}{f_{mm}(\bar{\ell}, m(a))} < 0$$

How does real GDP change with an increase in a — a negative shock to the intermediate goods producing technology?

$$Y(a) \equiv f(\bar{\ell}, m(a)) - am(a)$$

$$Y'(\hat{a}) = f_m(\bar{\ell}, m(a))m'(a) - am'(a) - m(a) = -m(a) < 0$$

A model with international trade

Suppose now that

m is imported intermediate inputs,

x is exports,

$p = a$ is terms of trade (real exchange rate)

Balanced trade

$$pm = x$$

Real GDP

$$c + x - p_0m = y - p_0m = f(\ell, m) - p_0m$$

where p_0 is price of imports (relative to exports) in the base year

Competitive economy continues to solve

$$\max_m f(\bar{\ell}, m) - pm$$

$$f_m(\bar{\ell}, m(p)) \equiv p$$

$$m'(p) = \frac{1}{f_{mm}(\bar{\ell}, m(p))} < 0$$

How does real GDP change with an increase in p — a deterioration in the terms of trade (depreciation in the real exchange rate)?

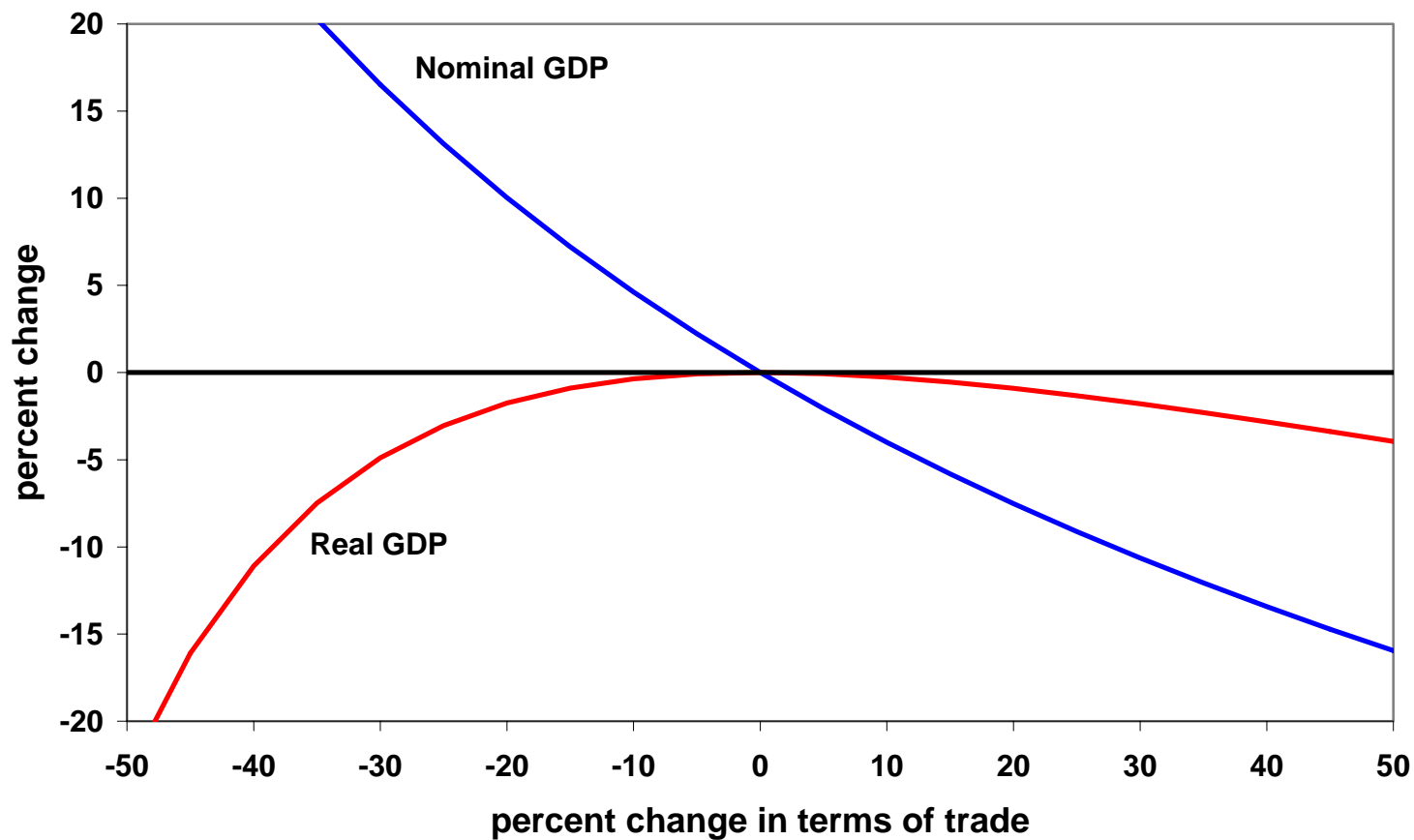
$$Y(p) \equiv f(\bar{\ell}, m(p)) - p_0 m(p)$$

$$Y'(p) = f_m(\bar{\ell}, m(p))m'(p) - p_0 m'(p) = (p - p_0)m'(p)$$

$$p \approx p_0 \Rightarrow Y'(p) \approx 0$$

Second-order effects for very large changes

terms of trade effects, import share = 0.30



Alternative accounting concepts

- Diewert and Morrison (1974, 1986)
- Kohli (1983, 1996)
- U.S. Bureau of Economic Analysis (Command Basis GDP)
- United Nations Statistics Division (Gross National Income)
- GNP, GDP (SNA, NIPA) do not.

Alternative accounting concepts

- Diewert and Morrison (1974, 1986)
- Kohli (1983, 1996)
- U.S. Bureau of Economic Analysis (Command Basis GDP)
- United Nations Statistics Division (Gross National Income)
- GNP, GDP (SNA, NIPA) do not.

Terms of trade shocks are worse than you think!

2. Real frictions waste outputs: our model

Small open economy (Mexico)

Produces nontradable goods, y_N , and tradable goods, y_D

- use intermediates plus capital and labor

Composite tradable $y_{Tt} = f(y_{Dt}, m_t)$

Frictions:

- sector specific capital
- costly to move labor across sectors

Quantitative model

Consumers

$$\max \sum_{t=0}^{\infty} \beta^t \left(\left[\varepsilon \left(\frac{c_{Tt}}{n_t} \right)^\rho + (1-\varepsilon) \left(\frac{c_{Nt}}{n_t} \right)^\rho \right]^{\frac{\psi}{\rho}} - 1 \right) / \psi$$

s.t.

$$p_{Tt} c_{Tt} + p_{Nt} c_{Nt} + q_t (i_{Dt} + i_{Nt}) + b_{t+1} = w_t \ell_t + (1+r_t) b_t + r_{Dt} k_{Dt} + r_{Nt} k_{Nt} + T_t$$
$$c_{Tt} \geq 0, c_{Nt} \geq 0, a_t \geq -A$$
$$b_0, k_{D0}, k_{N0} \text{ given}$$

Here

ℓ_t is working-age population,

$n_t = 0.5 \ell_t + 0.5 \text{pop}_t$ is adult-equivalent population,

Production functions

Domestically produced traded good

$$y_{Dt} = \min \left[z_{TDt} / a_{TD}, z_{NDt} / a_{ND}, A_D k_{Dt}^{\alpha_D} \ell_{Dt}^{1-\alpha_D} \right] - \Theta_D (\ell_{Dt-1}, \ell_{Dt}) \ell_{Dt-1}$$

$$\text{where } \Theta_D (\ell_{Dt-1}, \ell_{Dt}) = \theta_D \left(\frac{\ell_{Dt} - \ell_{Dt-1}}{\ell_{Dt-1}} \right)^2$$

Nontraded good

$$y_{Nt} = \min \left[z_{TNt} / a_{TN}, z_{NNt} / a_{NN}, A_N k_{Nt}^{\alpha_N} \ell_{Nt}^{1-\alpha_N} \right] - \Theta_N (\ell_{Nt-1}, \ell_{Nt}) \ell_{Nt-1}$$

$$\text{where } \Theta_N (\ell_{Nt-1}, \ell_{Nt}) = \theta_N \left(\frac{\ell_{Nt} - \ell_{Nt-1}}{\ell_{Nt-1}} \right)^2$$

Composite traded good (Armington aggregator)

$$y_{Tt} = M \left(\mu x_{Dt}^\zeta + (1 - \mu) m_t^\zeta \right)^{\frac{1}{\zeta}}$$

Investment good

$$i_{Dt} + i_{Nt} = G z_{TIt}^\gamma z_{NI t}^{1-\gamma}$$

$$k_{Dt+1} = \Phi(i_{Dt} / k_{Dt}) k_{Dt} + (1 - \delta) k_{Dt}$$

$$k_{Nt+1} = \Phi(i_{Nt} / k_{Nt}) k_{Nt} + (1 - \delta) k_{Nt}$$

$$\Phi(i/k) = \left[\left(\delta^{1-\eta} (i/k)^\eta - (1-\eta)\delta \right) / \eta \right]$$

Market clearing

Domestically produced traded good

$$x_{Dt} + x_{Ft} = y_{Dt}$$

Nontraded good

$$c_{Nt} + z_{NI} + z_{NDt} + z_{NNt} = y_{Nt}$$

Composite traded good

$$c_{Tt} + z_{TI} + z_{TDt} + z_{TNt} = y_{Tt}$$

Labor market

$$l_{Dt} + l_{Nt} = l_t$$

Balance of payments

$$m_t + b_{t+1} = p_{Dt} x_{Ft} + (1 + r_t) b_t$$

Foreign demand

$$x_{Ft} = D_t \left((1 + \tau_{Ft}) p_{Dt} \right)^{\frac{-1}{1-\zeta}}$$

Transfer of tariff revenue

$$T_t = \tau_{Dt} m_t$$

Sudden stop!

$$b_t = b_{t-1}, t = 1995, 1996$$

- agents do not foresee sudden stop
- agents do foresee length of sudden stop
- domestic interest rate is endogenously determined
- interest payments on foreign debt made at r^*

Calibration

Rest of world is U.S.

- 69% of imports to Mexico from U.S.
- 62% of foreign direct investment from U.S.
- $r^* = 5\% \Rightarrow \beta$

Elasticities

- subs. tradable and nontradable cons.: 0.5 (Kravis, et al.)
- intertemporal elasticity: 0.5
- subs. domestic tradable and imports: 2.0

Labor Adjustment ($\theta_D = \theta_N$)

- labor shift from sudden stop: 6.54%

Calibration continued

Set $\delta = 0.06$

Normalize prices in 1989 to 1

Mexico input-output table, 1989

- share parameters: $a_{TD}, a_{ND}, a_{TN}, a_{NN}, \alpha_D, \alpha_N, \varepsilon, \mu$
- scale parameters: A_D, A_N, M, D

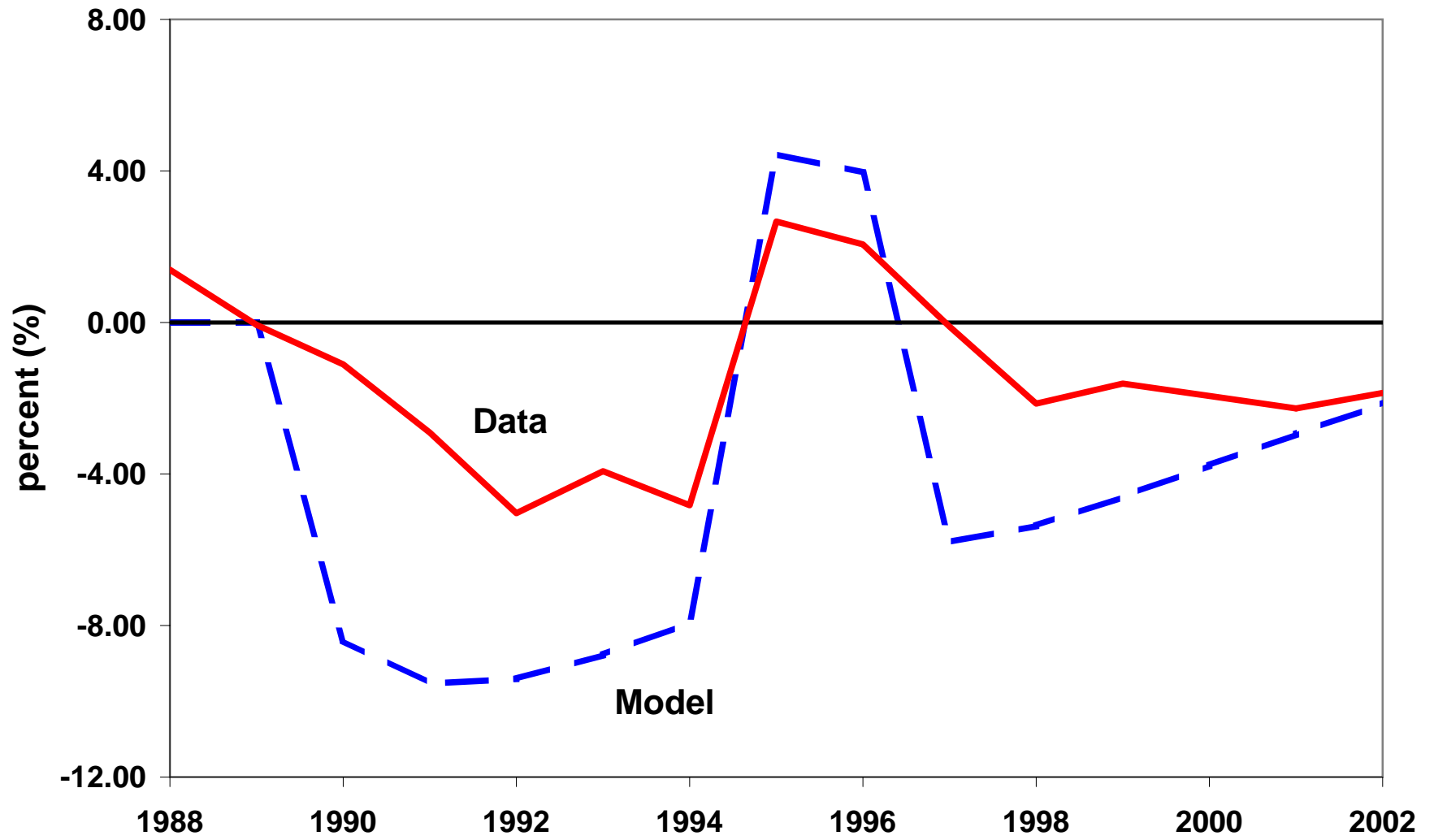
Input – Output Table, 1989

Commodity	Input			Final Demand				Total Demand
	Tradable	Nontradable	Total int. demand	Consumption	Investment	Exports	Total final demand	
Tradable	27.24	9.02	36.26	24.47	11.13	14.98	50.59	86.85
Nontradable	9.76	19.42	29.18	52.49	11.90	0.00	64.40	93.58
Total intermediate consumption	36.00	28.44	65.44	76.96	23.03	14.98	114.99	180.43
Employee compensation	21.29	43.71	65.00	0.00	0.00	0.00	0.00	65.00
Return to capital	13.58	21.42	35.00	0.00	0.00	0.00	0.00	35.00
Value added	34.87	65.13	100.00	0.00	0.00	0.00	0.00	100.00
Imports	14.98	0.00	14.98	0.00	0.00	0.00	0.00	14.98
Tariffs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Gross Output	86.85	93.58	180.42	76.96	23.03	14.98	114.99	295.41

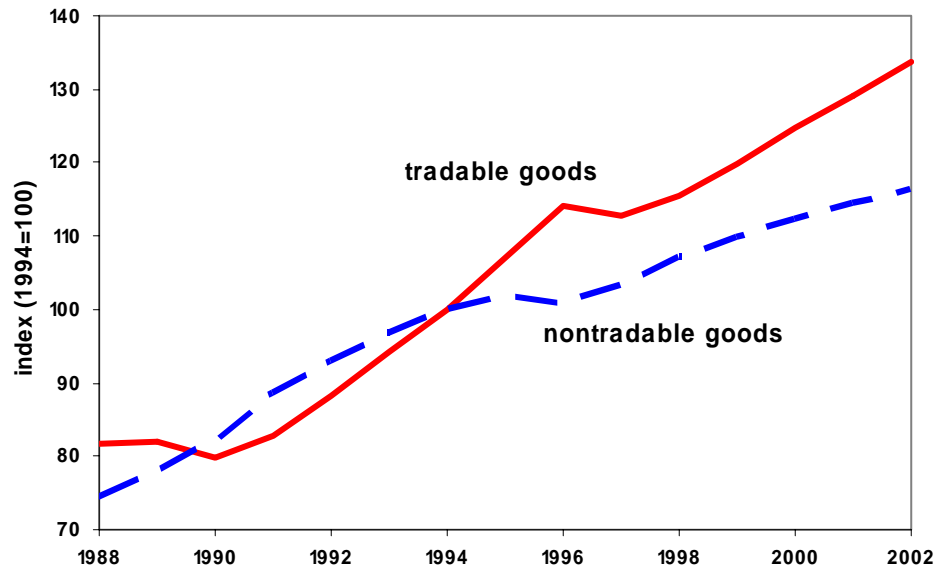
$$a_{TN} = \frac{z_{TN,1989}}{y_{N,1989}} = \frac{\text{Use Int.Tradables}}{\text{GO Nontradable}} = \frac{9.76}{93.58} = 0.10$$

$$w_{1989} \equiv 1 \Rightarrow \ell_{D,1989} = 21.29, \ell_{N,1989} = 43.71$$

Mexico: trade balance

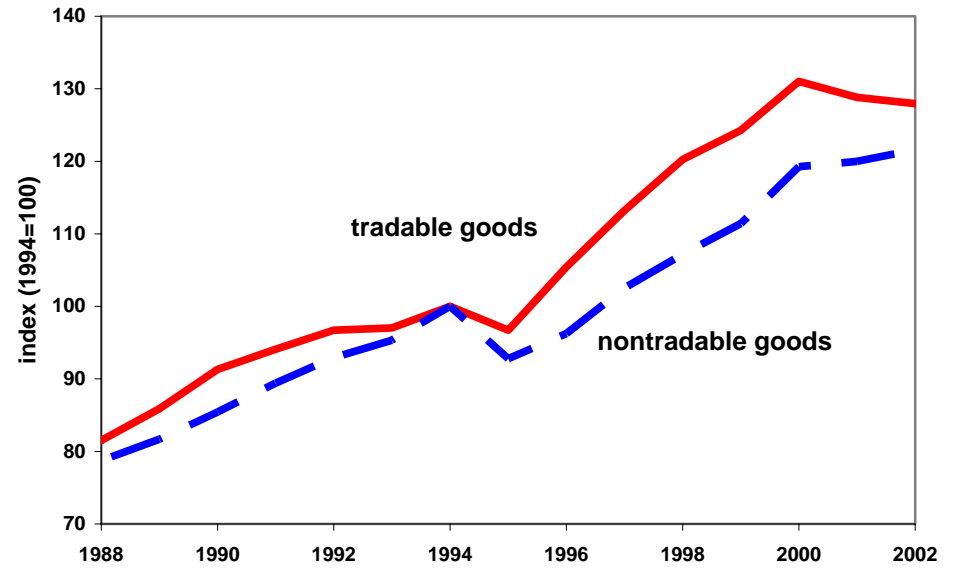


Mexico: sectoral value added



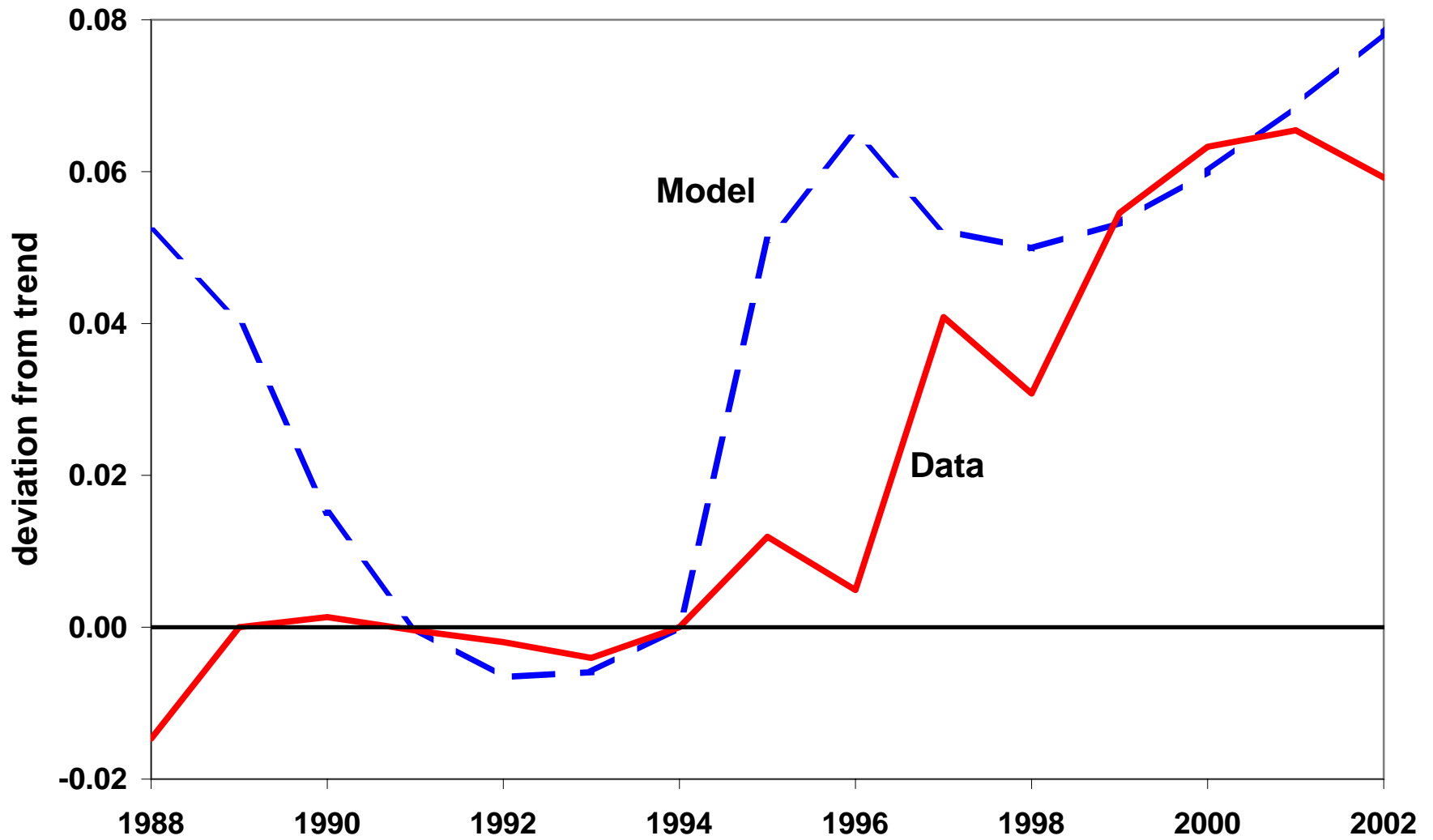
Model

Mexico: sectoral value added

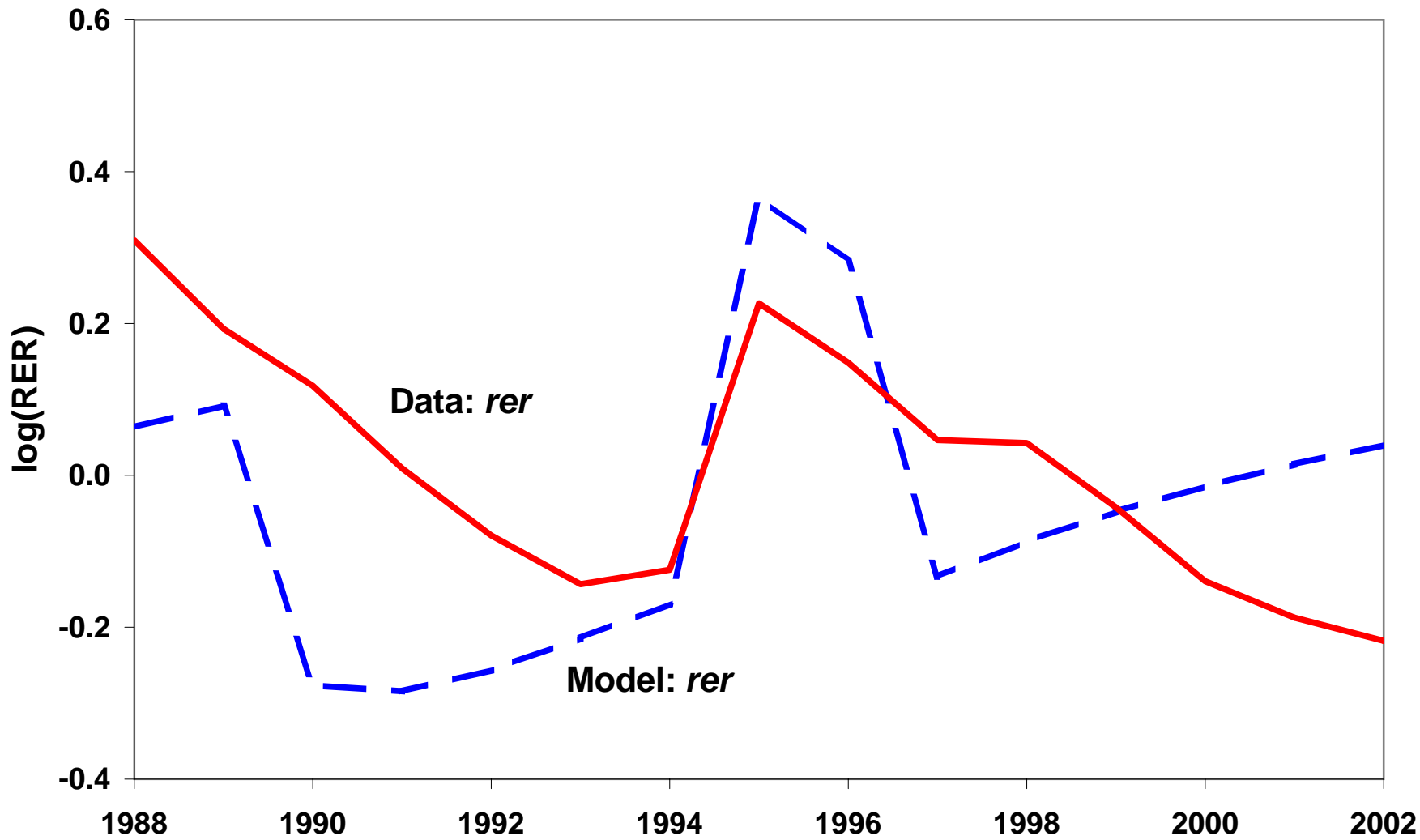


Data

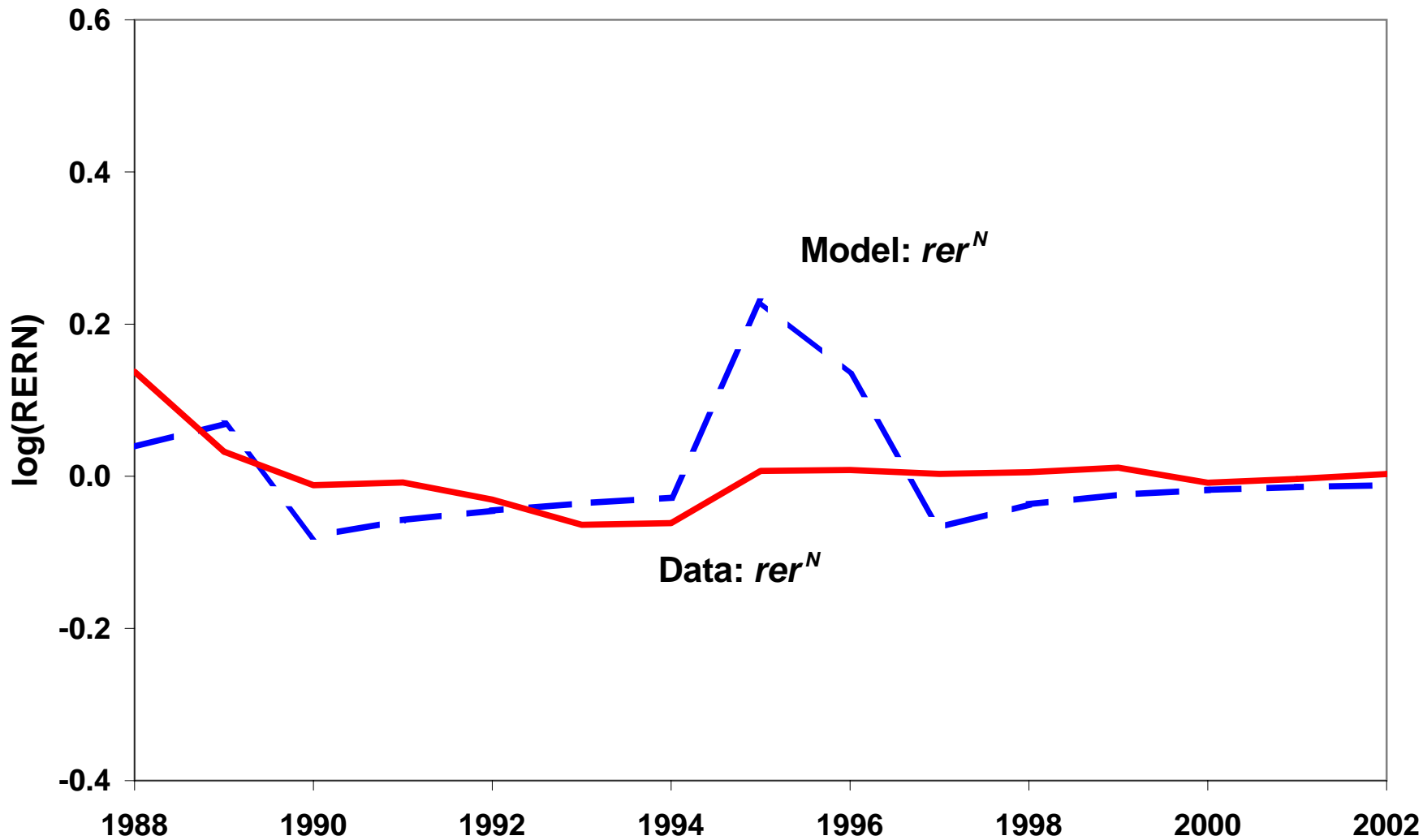
Mexico: traded good employment, detrended



Mexico: real exchange rates



Mexico: real exchange rates



Real GDP

$$Y_t = \left(p_{Dt_0} y_{Dt} - p_{Tt_0} z_{TDt} - p_{Nt_0} z_{NDt} \right) + \left(p_{Nt_0} y_{Nt} - p_{Tt_0} z_{TNt} - p_{Nt_0} z_{NNt} \right) + \tau_{Dt} m_t$$

Real Investment

$$I_t = p_{Tt_0} z_{TI t} + p_{Nt_0} z_{NI t}$$

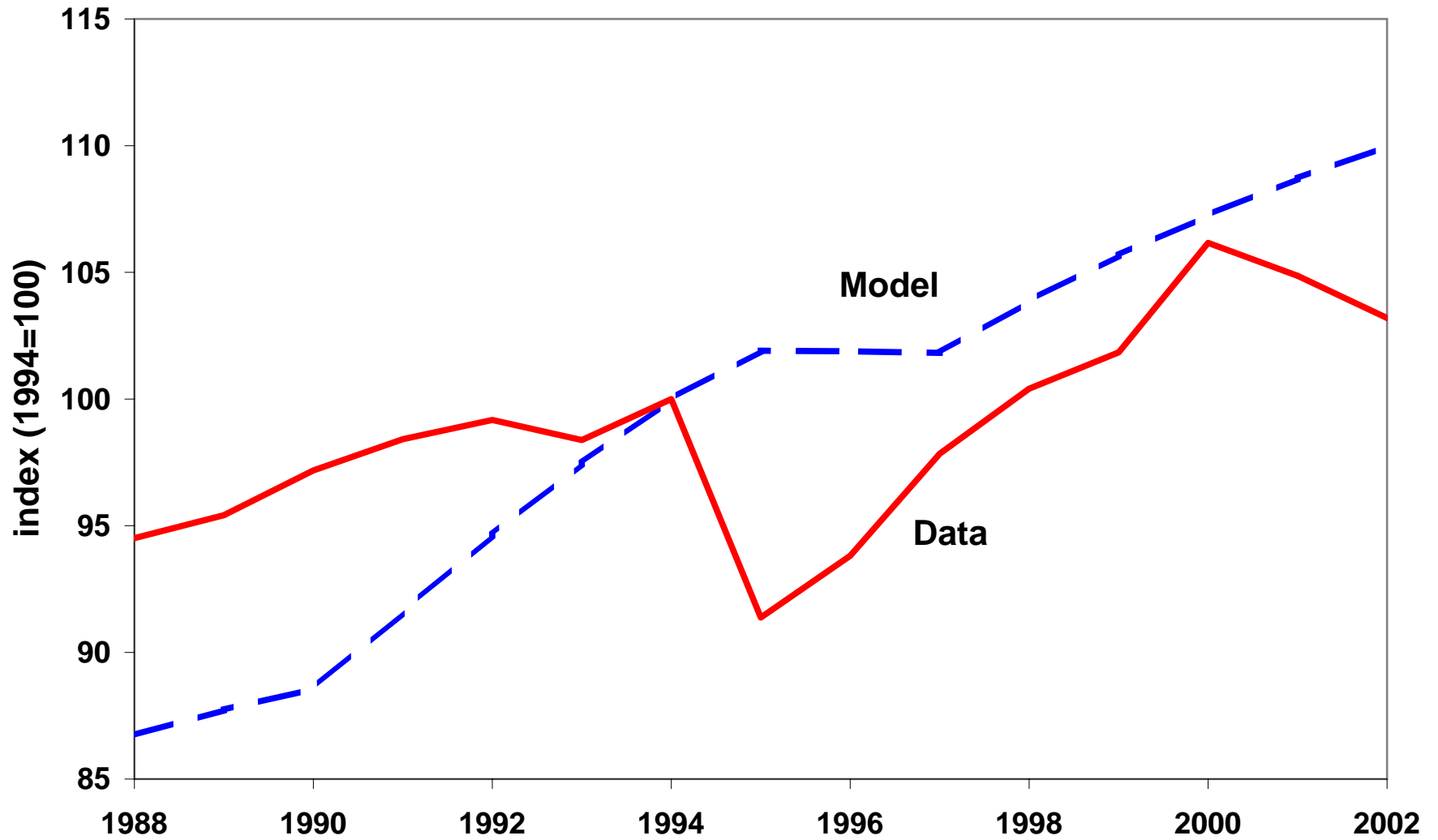
Real Capital Stock

$$K_{t+1} = (1 - \delta) K_t + I_t$$

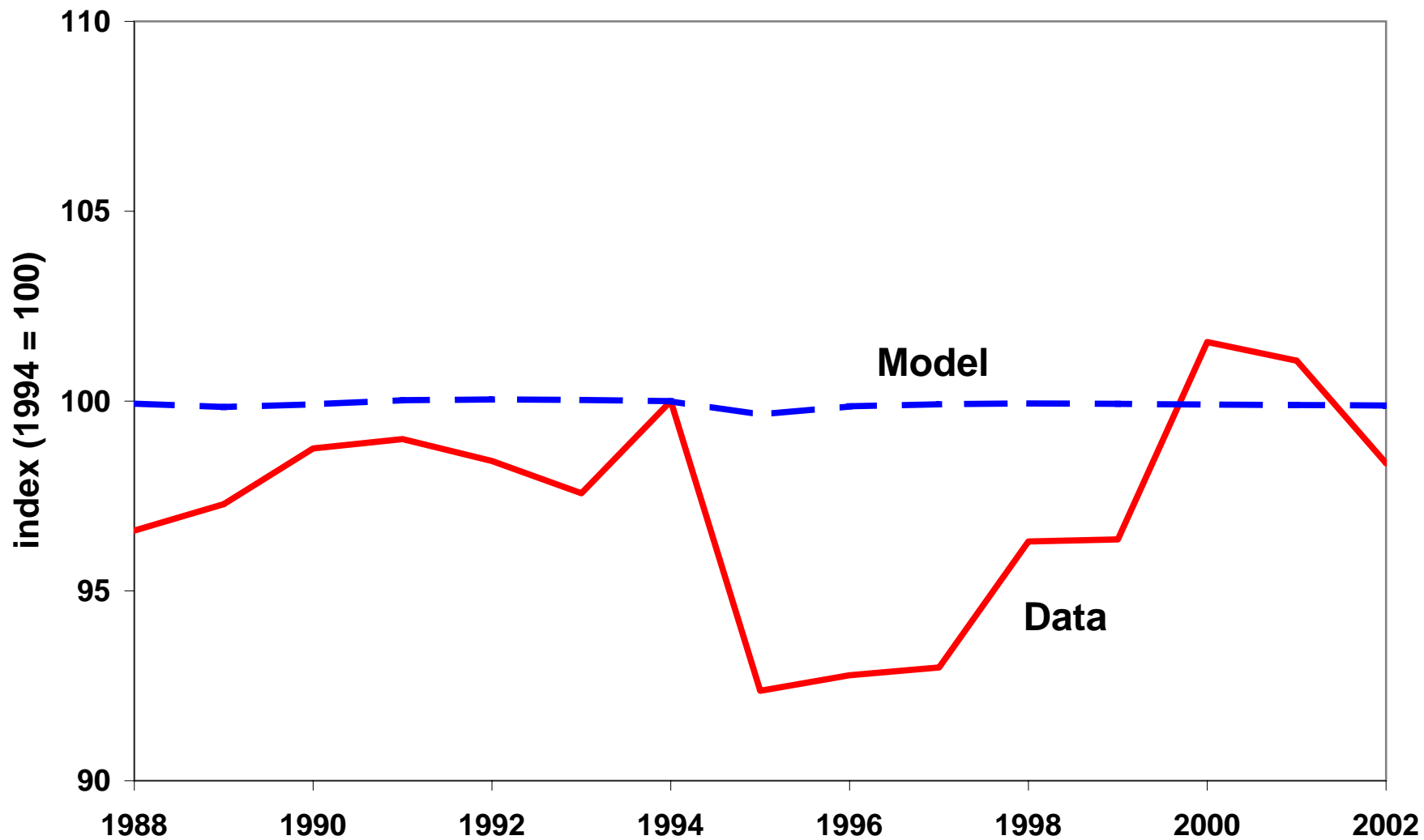
Total Factor Productivity

$$TFP_t = \frac{Y_t}{K_t^\alpha L_t^{1-\alpha}}$$

Mexico: GDP per working age person



Mexico: Total Factor Productivity



Extension: country risk premia

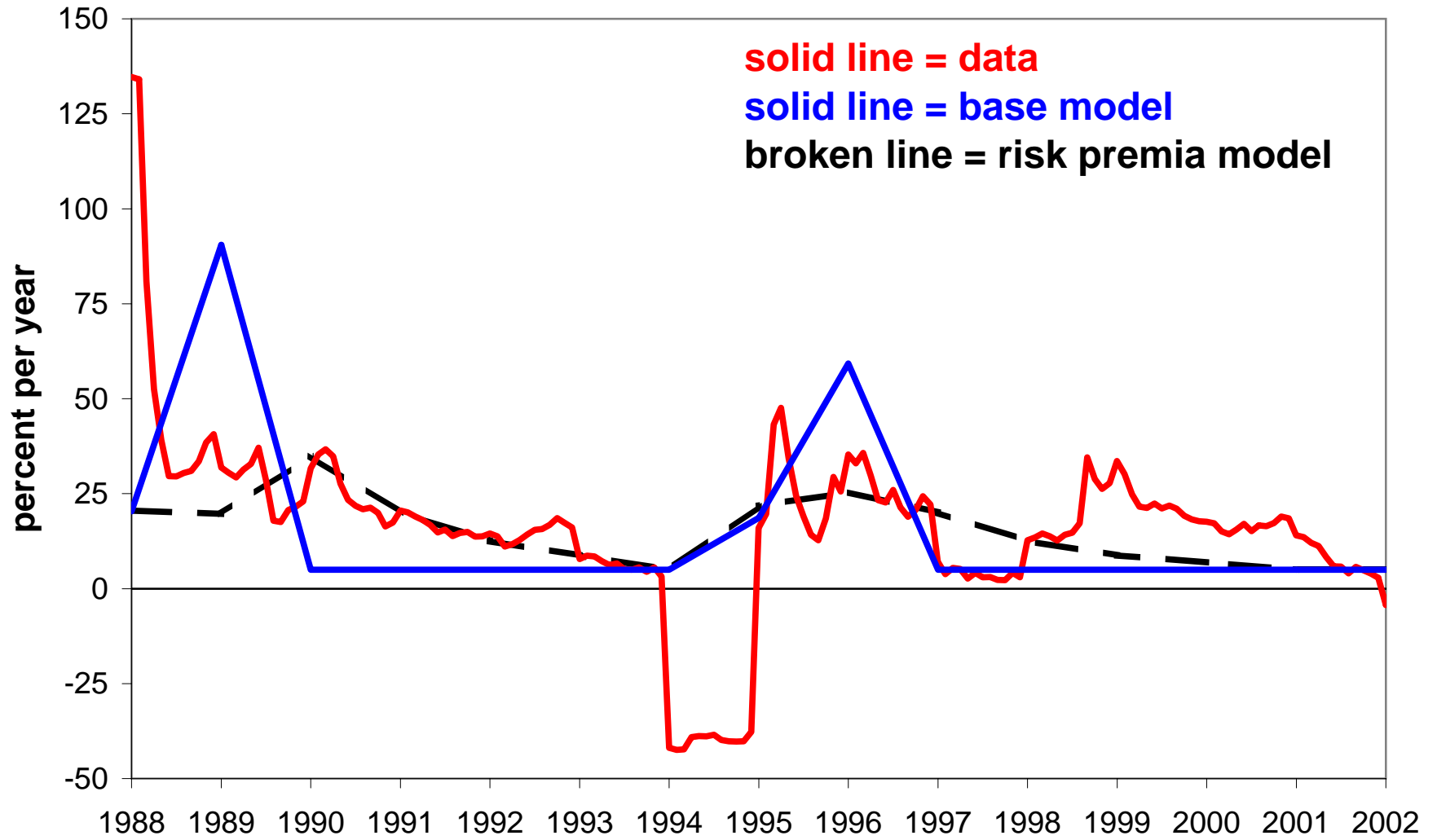
Adjusted return on Mexican T-bills higher than U.S.

- time-varying country specific risk premia

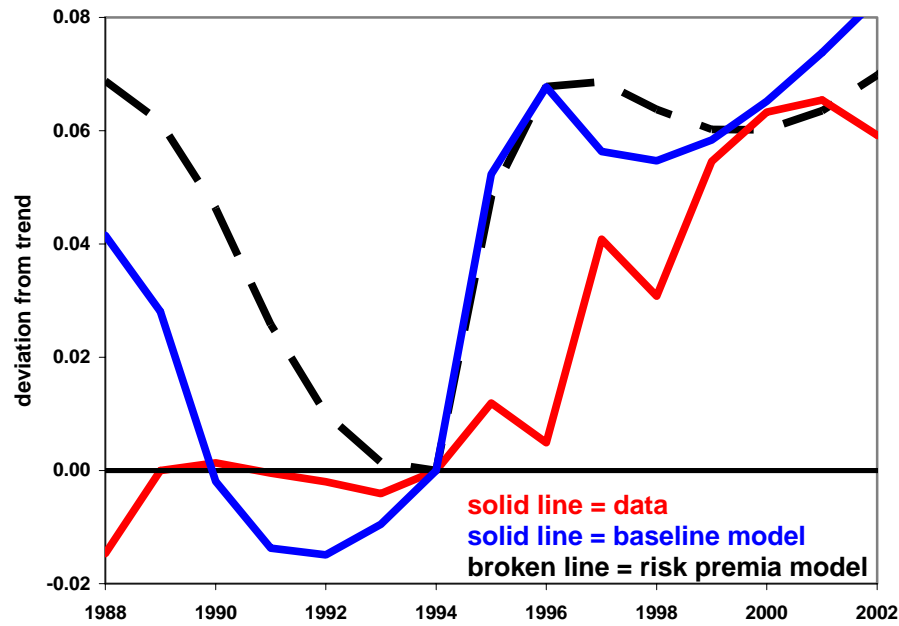
Take premia as exogenous

- $r_{mex,t}^* = \left(r^* + \sigma_{mex,t} \right)$

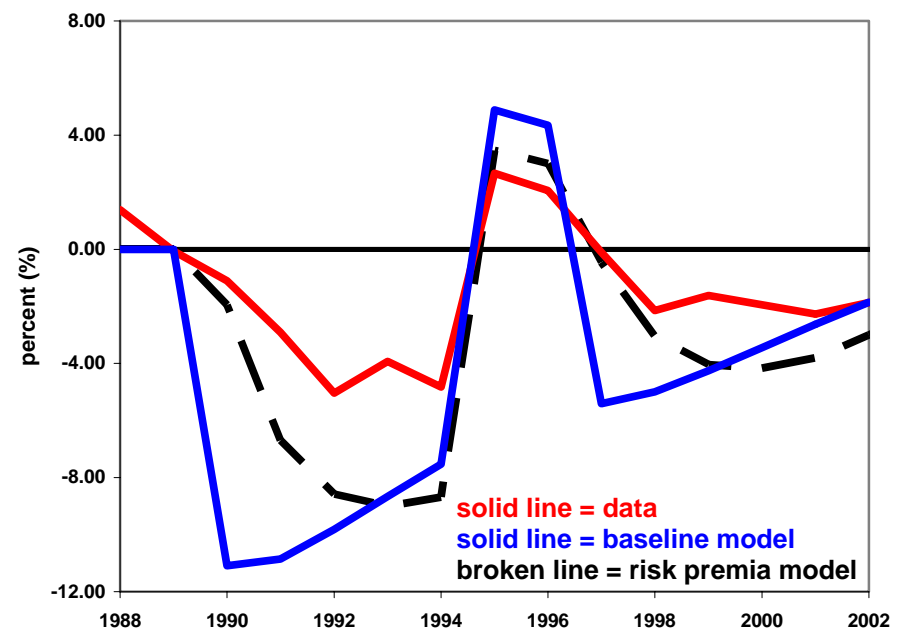
Mexico: interest rates



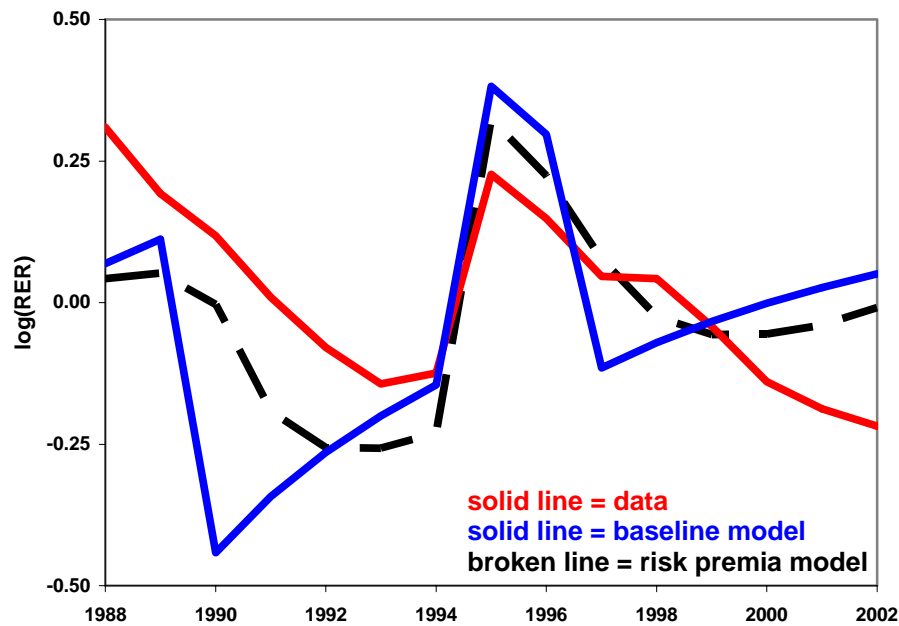
Mexico: traded good employment, detrended



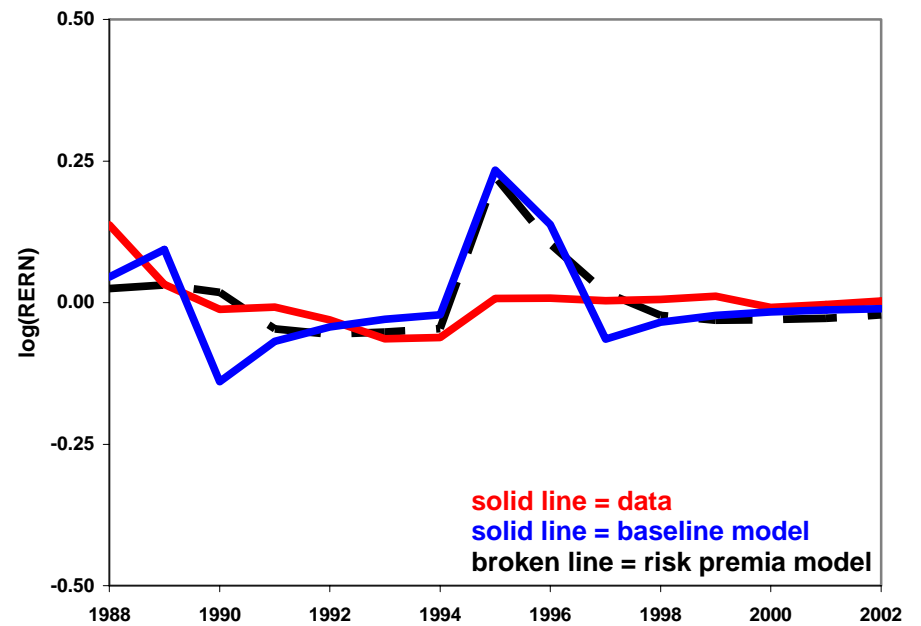
Mexico: trade balance



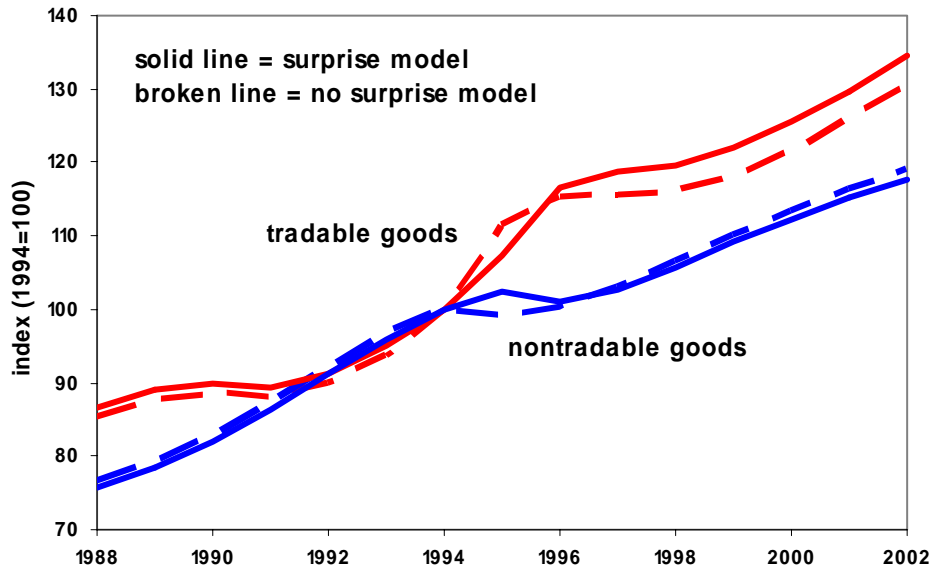
Mexico: real exchange rates



Mexico: nontraded/traded good prices

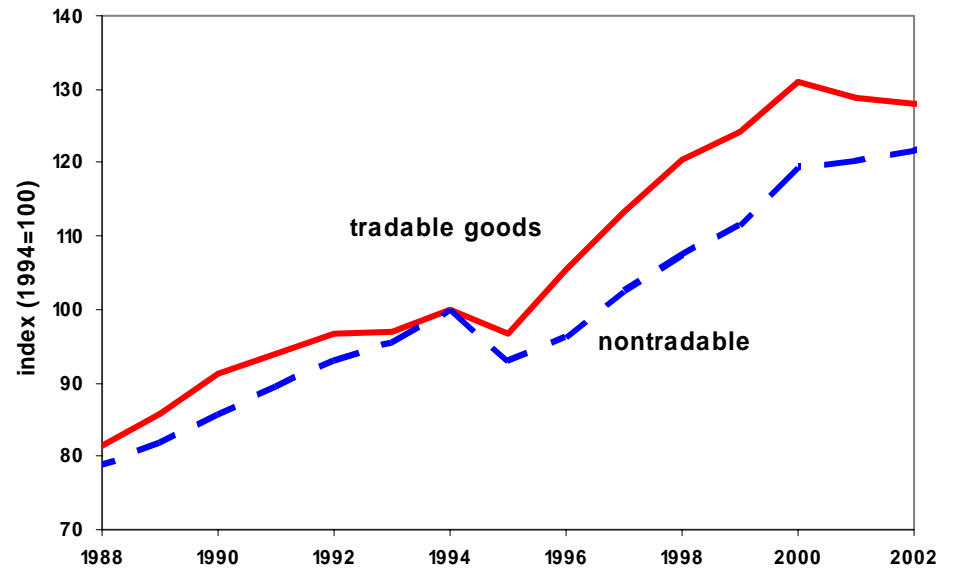


Mexico: sectoral value added



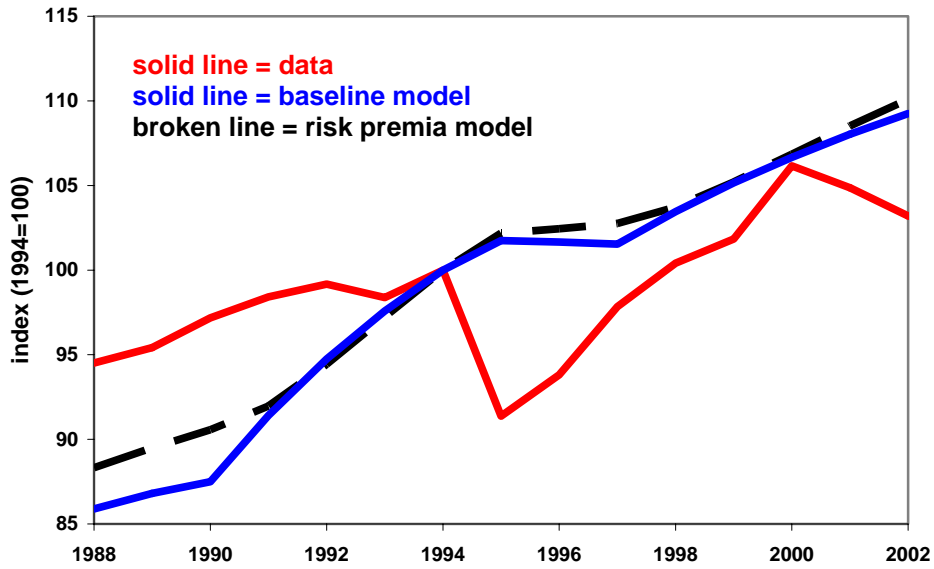
Model

Mexico: sectoral value added

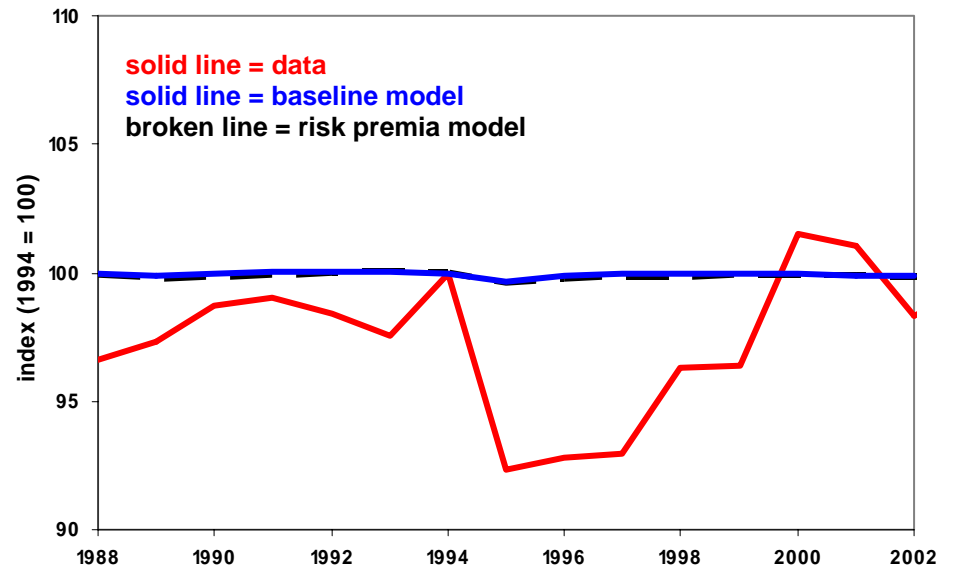


Data

Mexico: GDP per working age person



Mexico: Total Factor Productivity



Extension: foresight

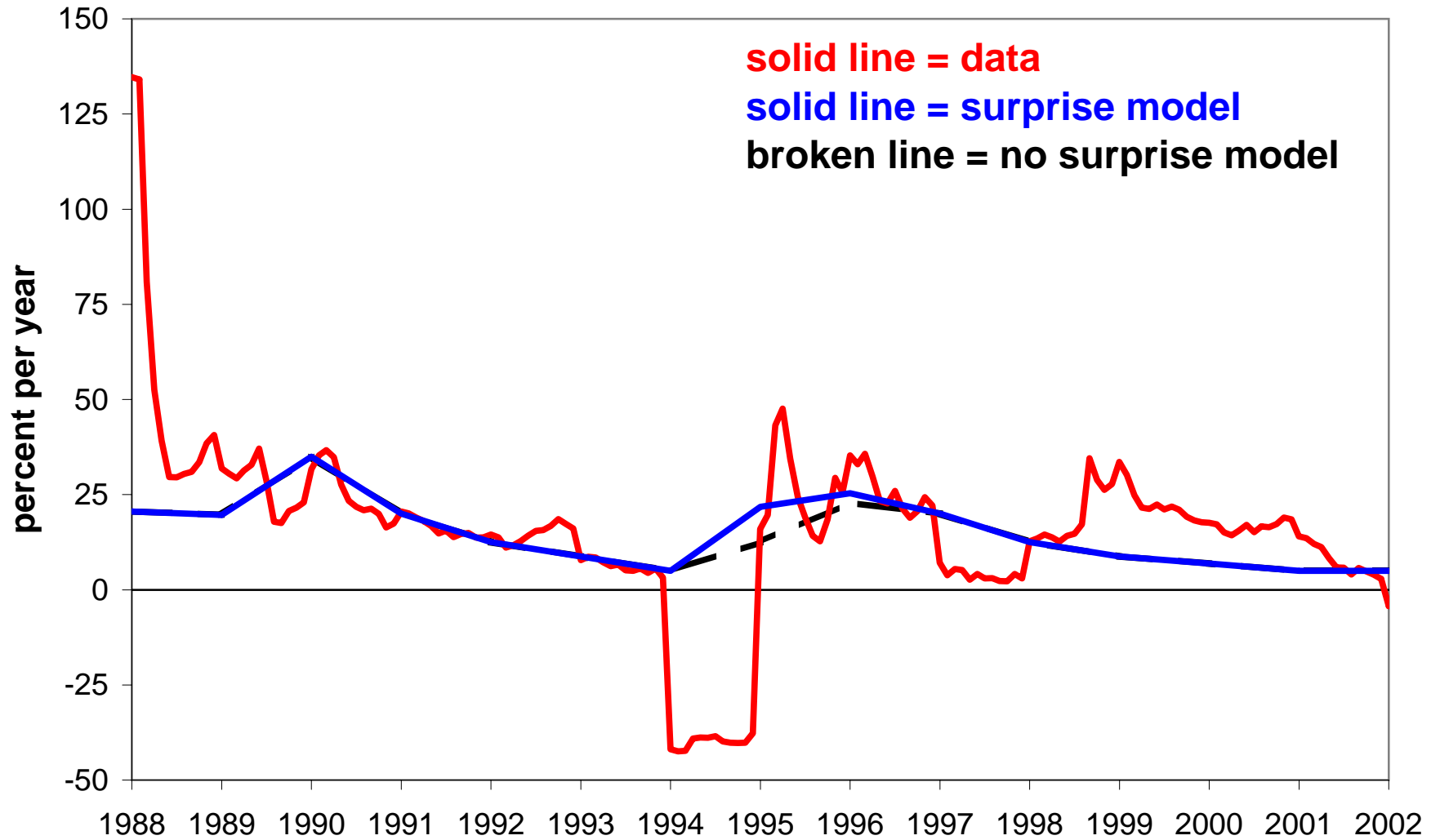
Agents know of sudden stop in 1994

- Agents do foresee length of sudden stop
- Domestic interest rate is endogenously determined

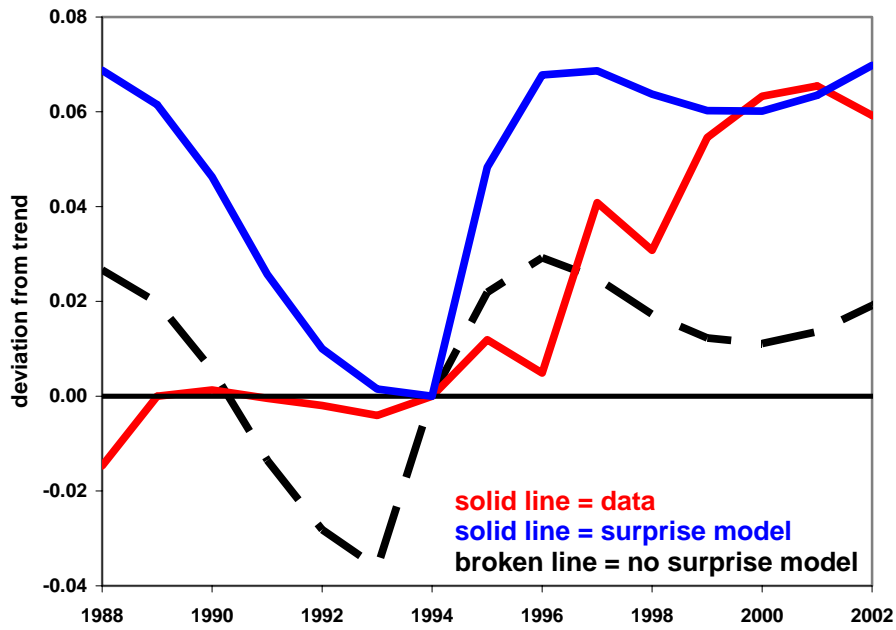
Take premia as exogenous

- $r_{mex,t}^* = (r^* + \sigma_{mex,t})$

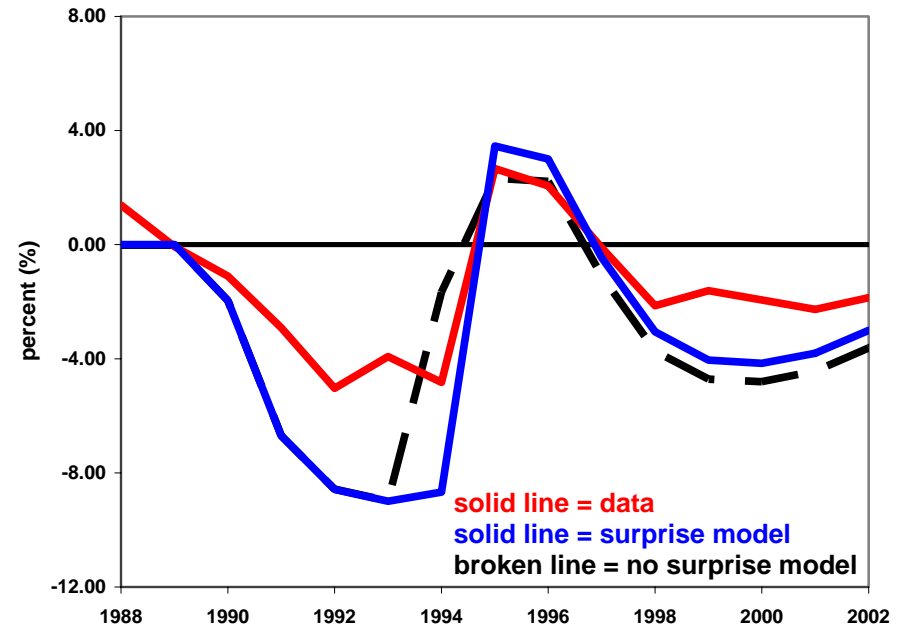
Mexico: interest rates



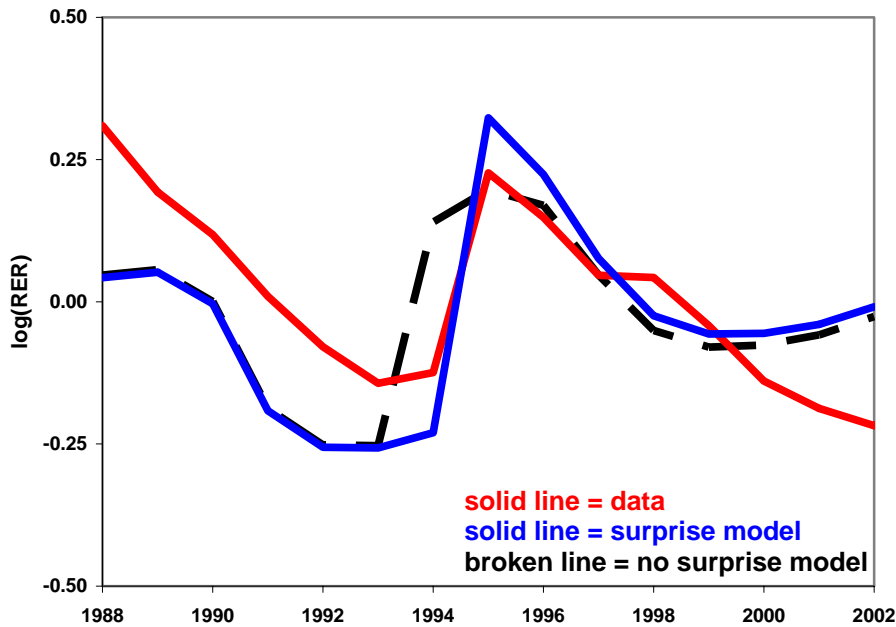
Mexico: traded good employment, detrended



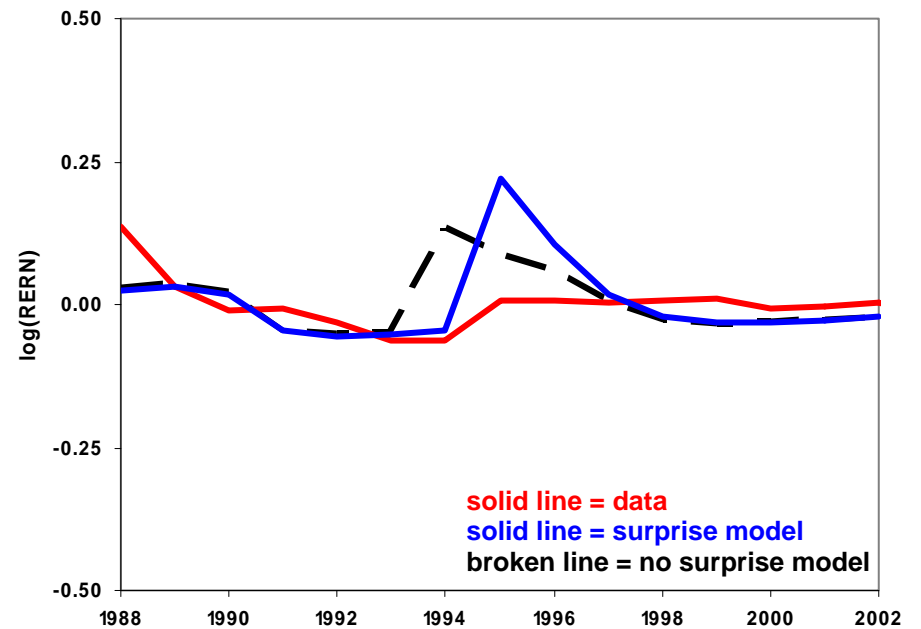
Mexico: trade balance



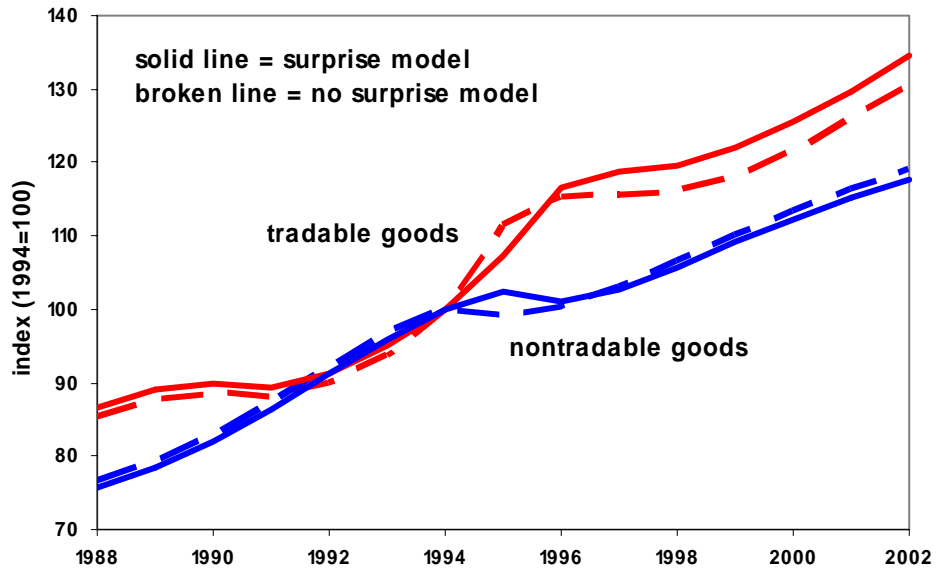
Mexico: real exchange rates



Mexico: nontraded/traded good prices

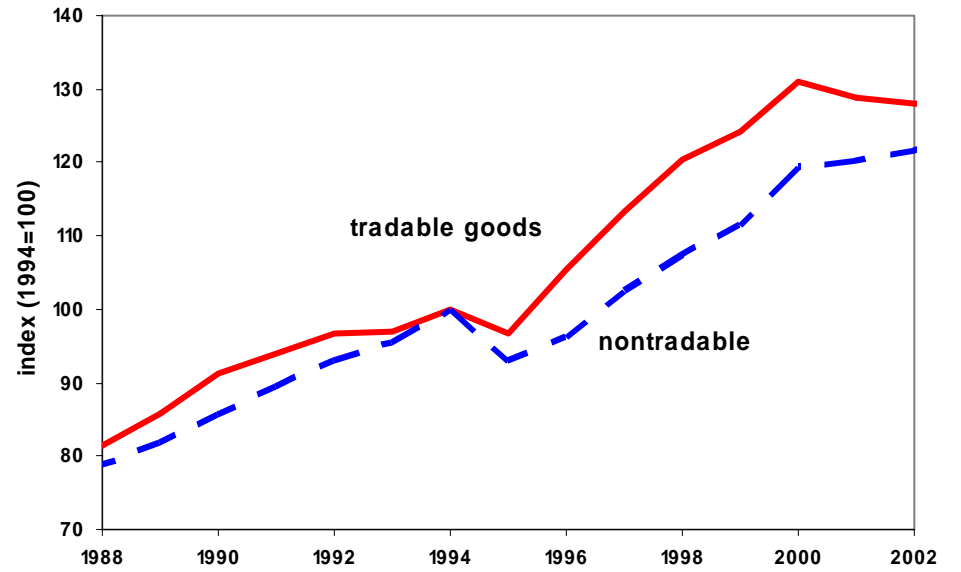


Mexico: sectoral value added



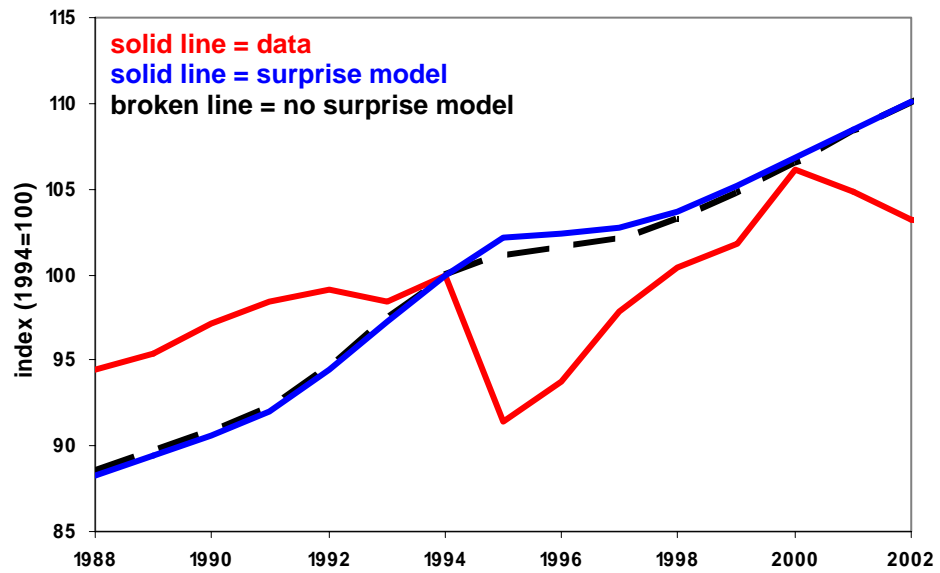
Model

Mexico: sectoral value added

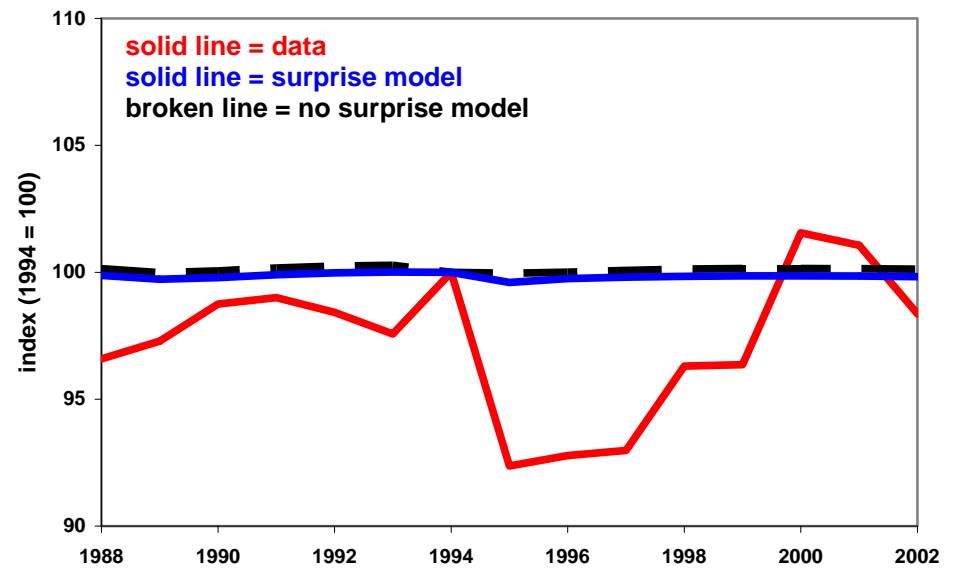


Data

Mexico: GDP per working age person



Mexico: Total Factor Productivity



Further Work

1. Leisure choice
2. Nonconvex adjustment

Conclusions

1. Sudden stops affect sectors differently
 - increase in p^T / p^N
 - tradable good output falls less than nontradable
 - labor reallocated to tradable good sector
2. International prices cannot affect GDP/TFP
3. Multisector model accounts for
 - real exchange rate
 - labor allocation
 - trade balance