Sudden Stops, Sectoral Reallocations, and Real Exchange Rates

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What Happens During a Sudden Stop?
Mexico 1994-95

Opens to capital flows: late 1980s

- trade deficits
- real exchange rate appreciation

Sudden stop: 1994-95

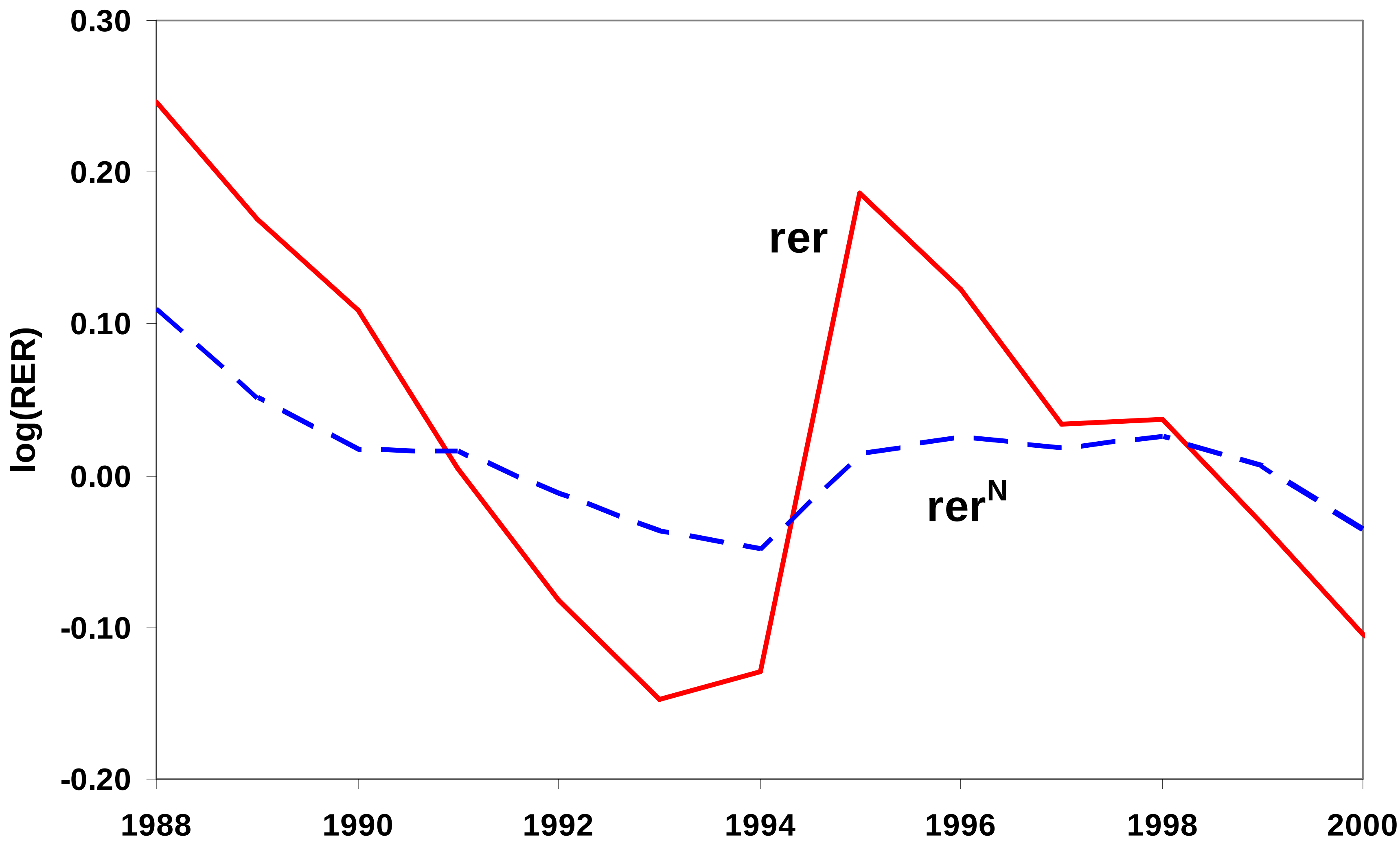
- trade surplus
- real exchange rate depreciation
- reallocation from nontraded goods to traded goods
- fall in GDP, TFP

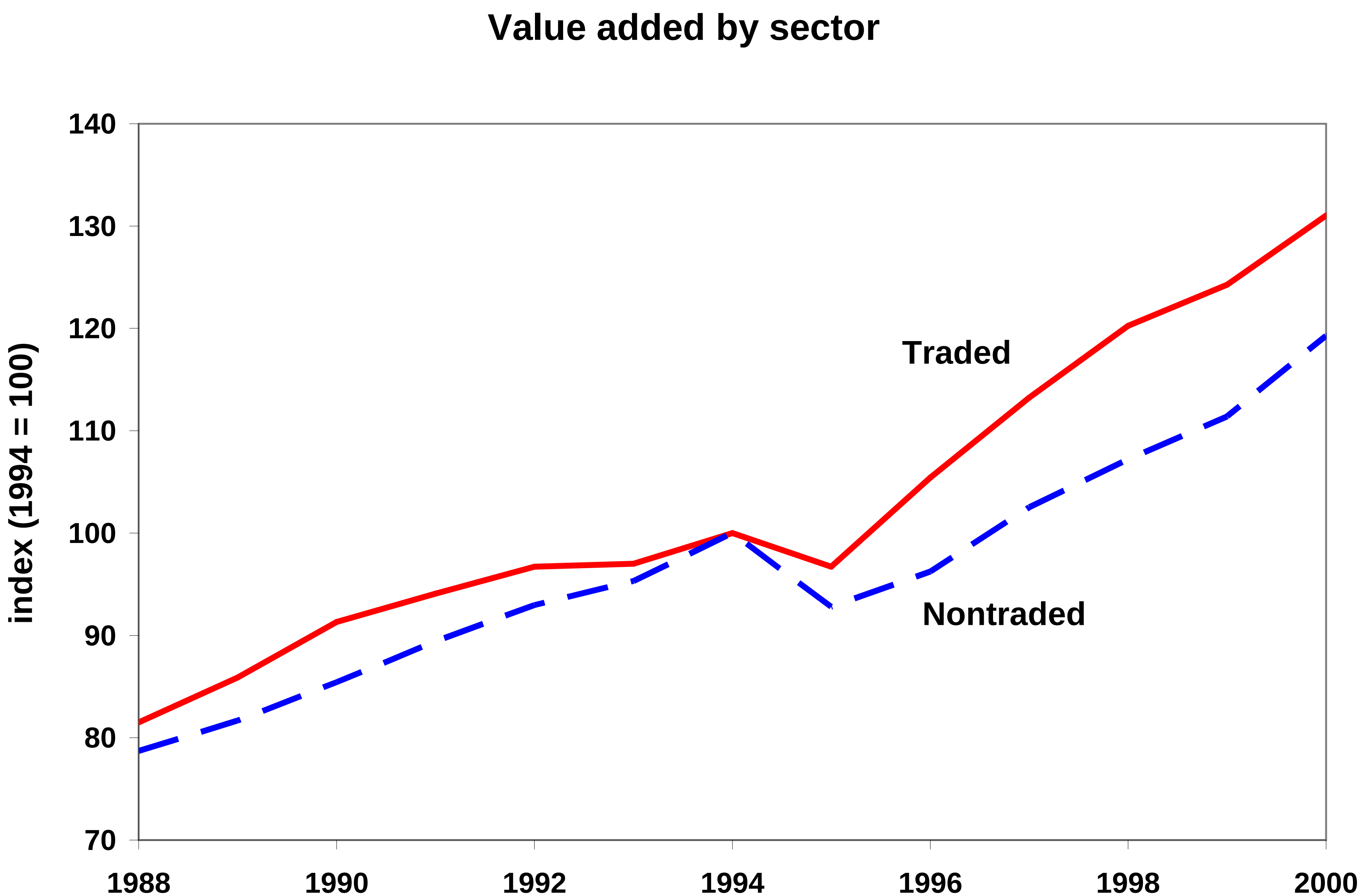
End of sudden stop

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

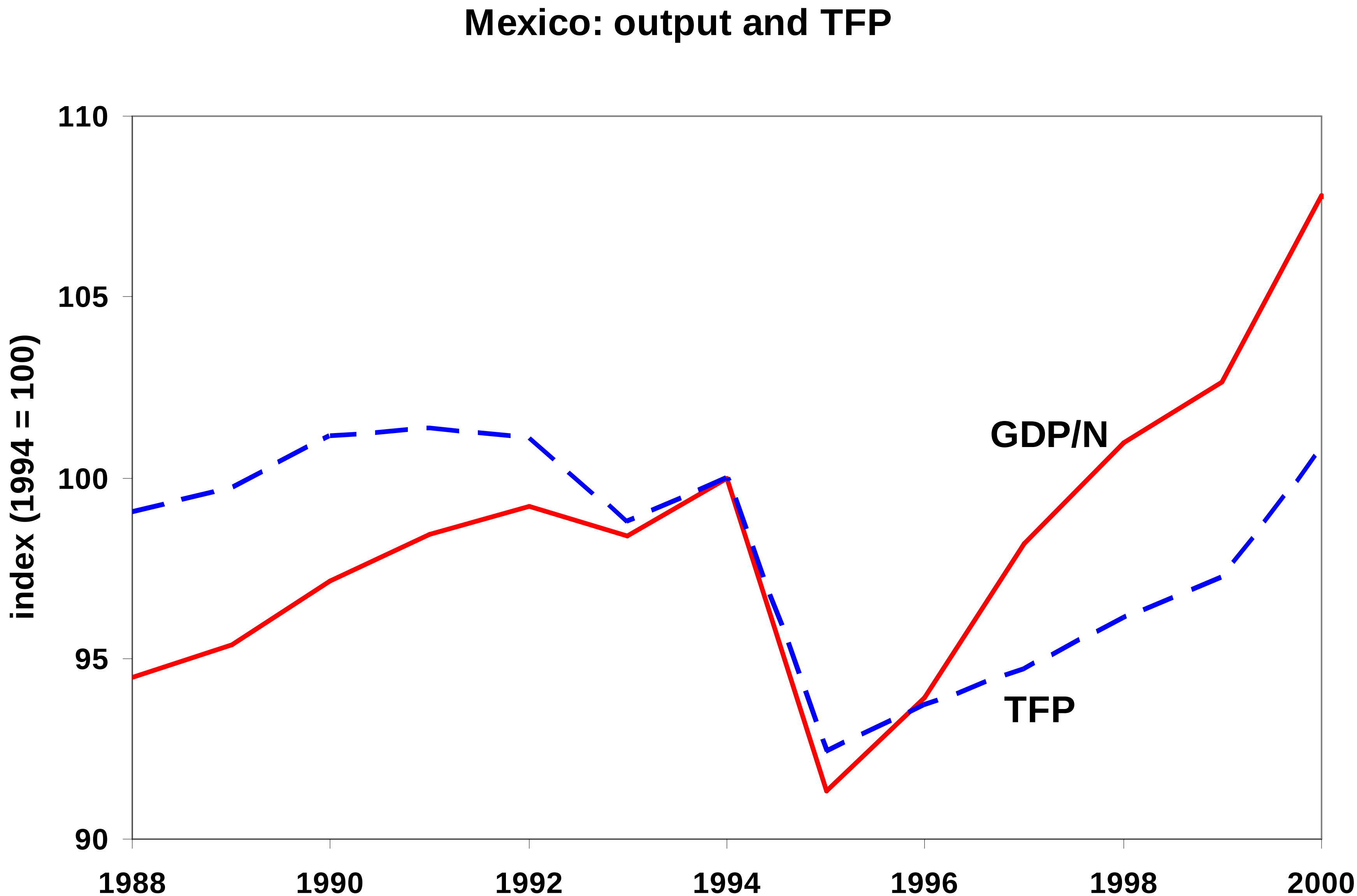

Mexico: trade balance
share of GDP (%)
4.0
2.0
0.0
-2.0
-4.0
-6.0
1988
1990
1992
1994
1996
1998
2000

Mexico-U.S. real exchange rate





Value added by sector
index (1994 = 100)
140
130
120
110
100
90
80
70
1988
1990
1992
1994
1996
1998
2000
Traded
Nontraded


Mexico: output and TFP
index (1994 = 100)
110
105
100
95
90
1988
1990
1992
1994
1996
1998
2000
GDP/N
TFP

Candidate Explanations

- labor hoarding
- variable capital utilization

Growth Accounting Discipline

Measured TFP must decline!

Our model

- Small open economy
  - multisector: traded, nontraded
  - costly to adjust labor across sectors
- Sudden stop
  - tradable good price increase, increase production
  - capital and labor misallocated
- Model accounts for:
  - real exchange rate, relative prices
  - trade balance
- Misses:
  - TFP, GDP

Model overview

- Growth model: small open economy

- Nontraded good, y_N, and domestic traded good, y_D
  - production use intermediates, capital, and labor

- Composite traded $y_{Tt} = f\left(y_{Dt}, m_t\right)$

- Frictions:
  - costly to move labor across sectors

- Quantitative model

Consumers

$$\max \sum_{t=1980}^{\infty} \beta^t u_t(c_{Tt}, c_{Nt}, \ell_t)$$

$$\text{s.t. } p_{Tt}c_{Tt} + p_{Nt}c_{Nt} + q_t i_t + b_{t+1} = w_t \ell_t + \left(1 + r_t\right) b_t + r_t k_t + T_t,$$

$$k_{t+1} = k_t\left(1-\delta\right) + i_t$$

initial conditions on k_{1988}, b_{1988}

where

$$u_t(c_{Tt}, c_{Nt}, \ell_t) = \frac{1}{\psi}\left(\left(\varepsilon\left(\frac{c_{Tt}}{n_t}\right)^{\rho} + \left(1-\varepsilon\right)\left(\frac{c_{Nt}}{n_t}\right)^{\rho}\right)^{\frac{\eta\psi}{\rho}}\left(\frac{\overline{\ell}_t - \ell_t}{\overline{\ell}_t}\right)^{(1-\eta)\psi} - 1\right).$$

We also experiment with a quasi-linear utility function

$$u(c_{Tt}, c_{Nt}, \ell_t) = \frac{1}{\psi}\left(\left(\left(\varepsilon\left(\frac{c_{Tt}}{n_t}\right)^{\rho} + (1-\varepsilon)\left(\frac{c_{Nt}}{n_t}\right)^{\rho}\right)^{\frac{1}{\rho}} - \lambda g^t\left(\frac{\ell_t}{\overline{\ell}_t}\right)^{\eta}\right)^{\psi} - 1\right).$$

which, when $\psi = 0$, is

$$u(c_{Tt}, c_{Nt}, \ell_t) = \log\left(\left(\varepsilon\left(\frac{c_{Tt}}{n_t}\right)^{\rho} + (1-\varepsilon)\left(\frac{c_{Nt}}{n_t}\right)^{\rho}\right)^{\frac{1}{\rho}} - \lambda g^t\left(\frac{\ell_t}{\overline{\ell}_t}\right)^{\eta}\right).$$

No income effects on labor supply.

Production functions

Domestically produced traded good

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

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

Nontraded good

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

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

Base case sets $\Theta_{Dt}\left(\ell_{Dt-1}, \ell_{Dt} \right) = \Theta_{Nt}\left(\ell_{Nt-1}, \ell_{Nt} \right) = 0$.

Composite traded good (Armington aggregator)

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

Foreign demand

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

Investment good

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

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

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

Balance of payments

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

Market clearing.

Exogenous processes

- Country interest rate premia, σ_t^{mex}

  1. with access to international capital

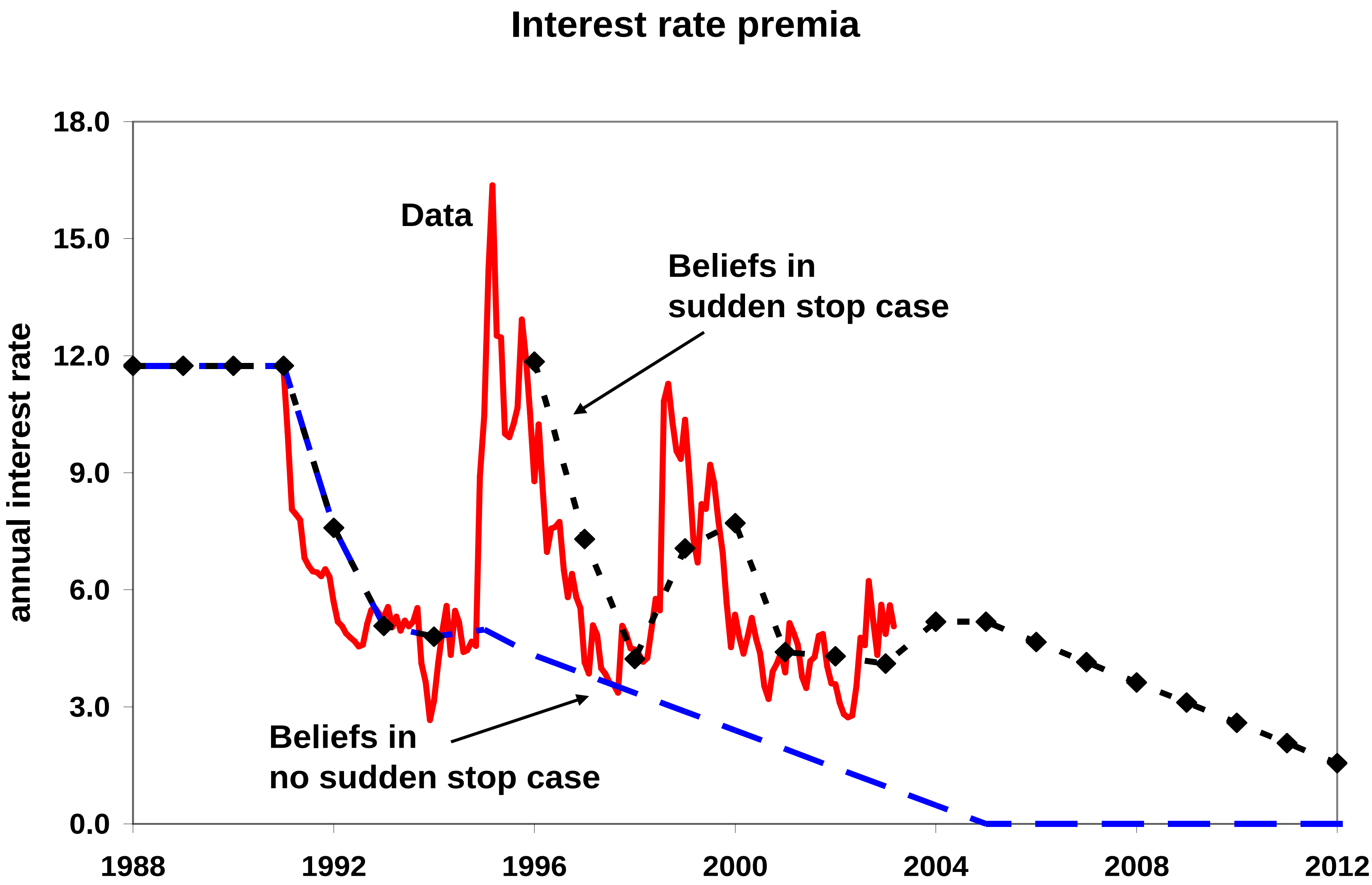
     $$r_t^{mex} = r^* + \sigma_t^{mex}$$

  2. without access to international capital

     r_t^{mex} is domestically determined

- Adult equivalent populations, n_t, and working age population, $\bar{\ell}_t$

- Mexican tariff rates, τ_{Dt}, and world tariff rates, τ_{Ft}



Interest rate premia
annual interest rate
18.0
15.0
12.0
9.0
6.0
3.0
0.0
1988
1992
1996
2000
2004
2008
2012
Data
Beliefs in
sudden stop case
Beliefs in
no sudden stop case

Calibration

Rest of world is U.S.

- 72% of imports to Mexico from U.S. (1988-2000)
- 60% of foreign direct investment from U.S. (1988-2000)
- $r^* = 0.04 \Rightarrow \beta$

Elasticities

- traded versus nontraded consumption: 0.5 (Kravis, et al.)
- intertemporal elasticity: 0.5
- domestic traded versus imports: 2.0

Labor Adjustment $\left(\theta_D = \theta_N\right)$

- labor shift from sudden stop: 6.7%

Calibration continued

Set $\delta = 0.06$ so that $\delta K_{1988} / Y_{1988} = 0.11$

Normalize prices in 1988 to 1

1988 Mexican input-output matrix

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

Interest rate in 1988: $r_{1988}^{mex} = 0.1574$

Tax on capital income in 1989 to match 1988 investment:

- $\tau_{K1989} = 0.20$

Exogenous growth:

- $g = 1.02$

1988 Input-Output Matrix

Commodity	Input: Traded	Input: Nontraded	Input: Total int. demand	Final Demand: Consumption	Final Demand: Investment	Final Demand: Exports	Final Demand: Total final demand	**Total Demand**
Traded	33.54	**9.28**	42.82	27.05	10.16	19.93	57.14	99.96
Nontraded	13.13	20.53	33.66	49.00	12.40	0.00	61.40	95.06
Total intermediate consumption	46.67	29.81	76.48	76.05	22.56	19.93	118.54	195.02
Employee compensation	**22.11**	**38.74**	60.85					60.85
Return to capital	10.79	26.51	37.30					37.30
Value added	32.89	65.26	98.15					98.15
Imports	18.54	0.00	18.54					18.54
Tariffs	1.85	0.00	1.85					1.85
Total Gross Output	99.96	**95.06**	195.02	76.05	22.56	19.93	118.54	313.56

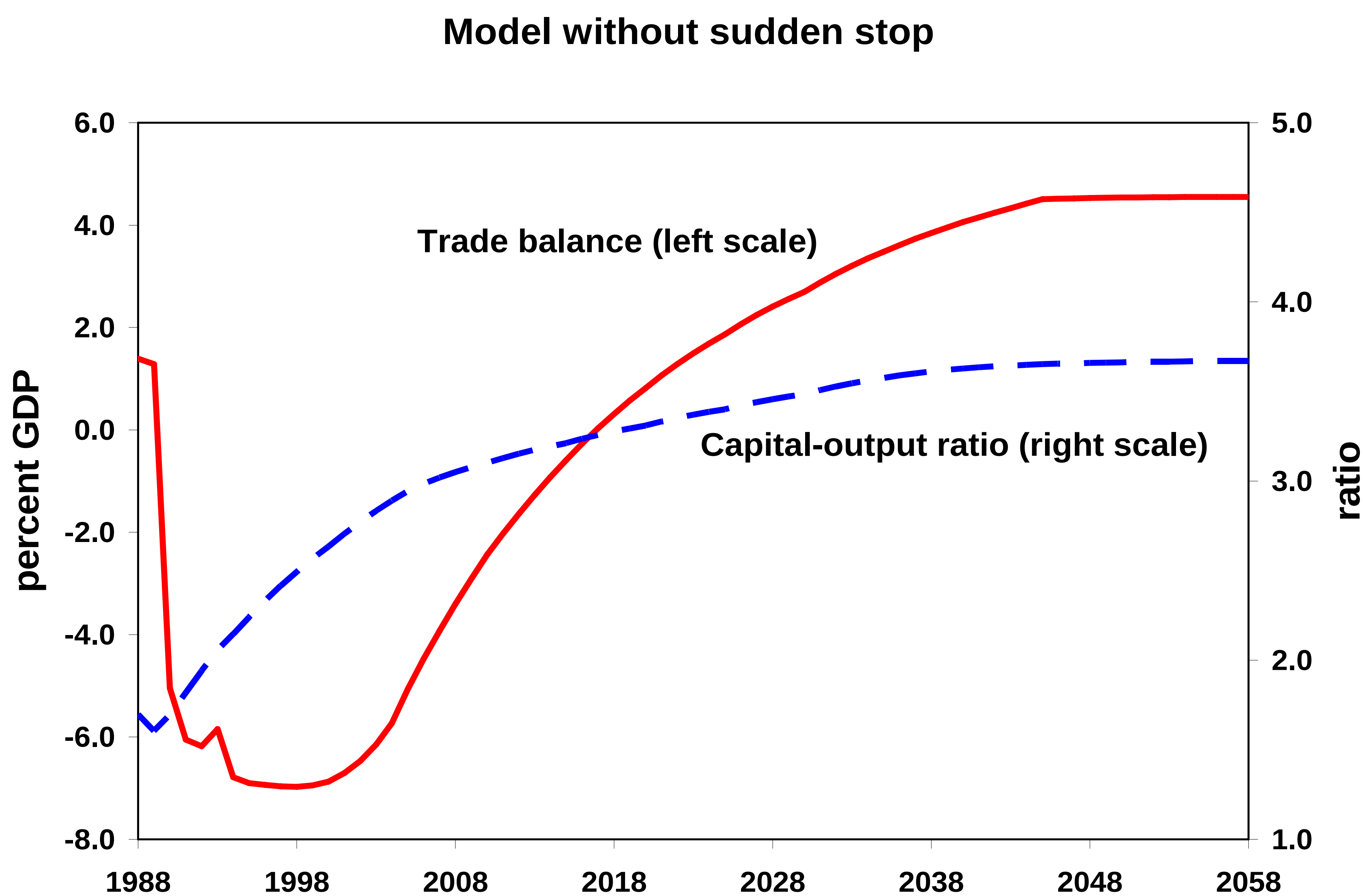
$$a_{TN} = \frac{z_{TN1988}}{y_{N1988}} = \frac{intermediate\ input\ \ traded}{gross\ output\ nontraded} = \frac{9.28}{95.06} = 0.10$$

$$w_{1988} = 1 \Rightarrow \ell_{D1988} = 22.11,\ \ell_{N1989} = 38.74$$

Calibration of model

Parameter	Value	Statistic	Target
Consumer parameters			
b_{1988}	-8.831	Trade balance to GDP in 1988, in percent	1.390
k_{1988}	169.817	Real interest rate in 1988, in percent	15.740
β	0.987	U.S. real interest rate, in percent	4.000
ε	0.234	Traded good share in consumption in 1988	0.356
ρ	-1.000	Elasticity of substitution: traded to nontraded	0.500
η	0.306	Ratio of hours worked to available hours in 1988	0.267
ψ	-1.000	Intertemporal elasticity of substitution	0.500
δ	0.062	Depreciation to GDP in 1988, in percent	10.566
τ_{K1989}	0.201	Investment in 1988	22.561
Producer parameters			
a_{TD}	0.422	Share of traded inputs in domestic traded in 1988	0.422
a_{ND}	0.165	Share of nontraded inputs in domestic traded in 1988	0.165
a_{TN}	0.098	Share of traded inputs in domestic nontraded in 1988	0.098
a_{NN}	0.216	Share of nontraded inputs in domestic nontraded in 1988	0.216
A_D	2.770	Traded gross output in 1988	79.564
A_N	1.546	Nontraded gross output in 1988	95.065
α_D	0.328	Capital's share of domestic traded value added in 1988	0.328

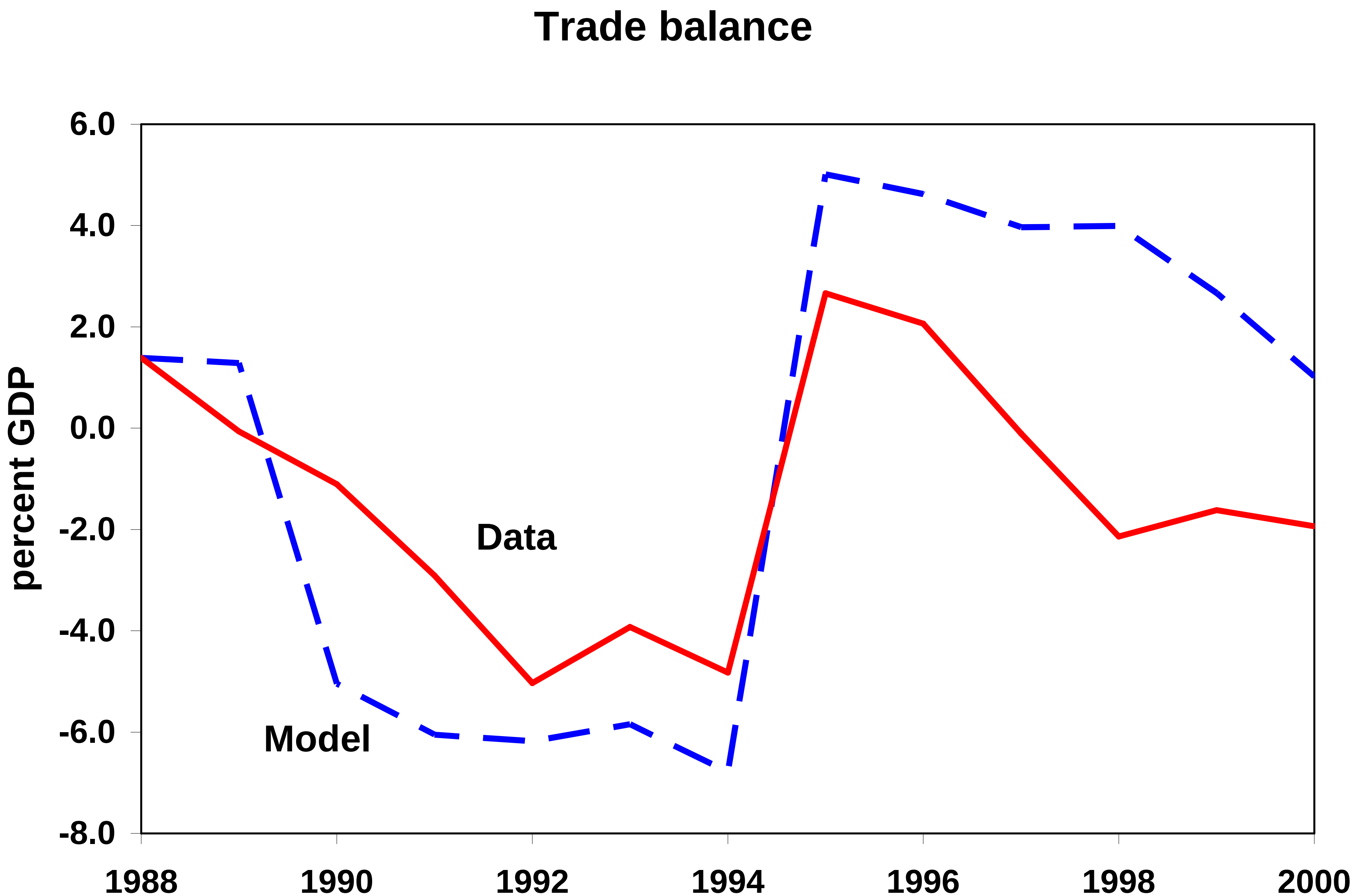
α_N	0.406	Capital's share of nontraded value added in 1988	0.406
γ	0.450	Share of traded inputs in investment good production in 1988	0.450
G	1.990	Investment in 1988	22.561
g	1.020	Growth rate of U.S. GDP per working age person, percent	2.000
Trade parameters			
M	1.866	Total traded goods in 1988	99.955
μ	0.653	Ratio of imports to domestic traded good in 1988	0.233
ζ	0.500	Elasticity of substitution: domestic traded to imports	2.000
D_{1988}	21.141	Exports in 1988	19.928
Time series of parameters			
$\bar{\ell}_t$		Mexican working age population data and projections	
n_t		Mexican adult equivalent population data and projections	
σ_t		Mexican interest premia	
D_t		U.S. working age population data and projections	
τ_t		Mexican tariffs on U.S. imposts	
τ_{Ft}		U.S. tariffs on Mexican imports	

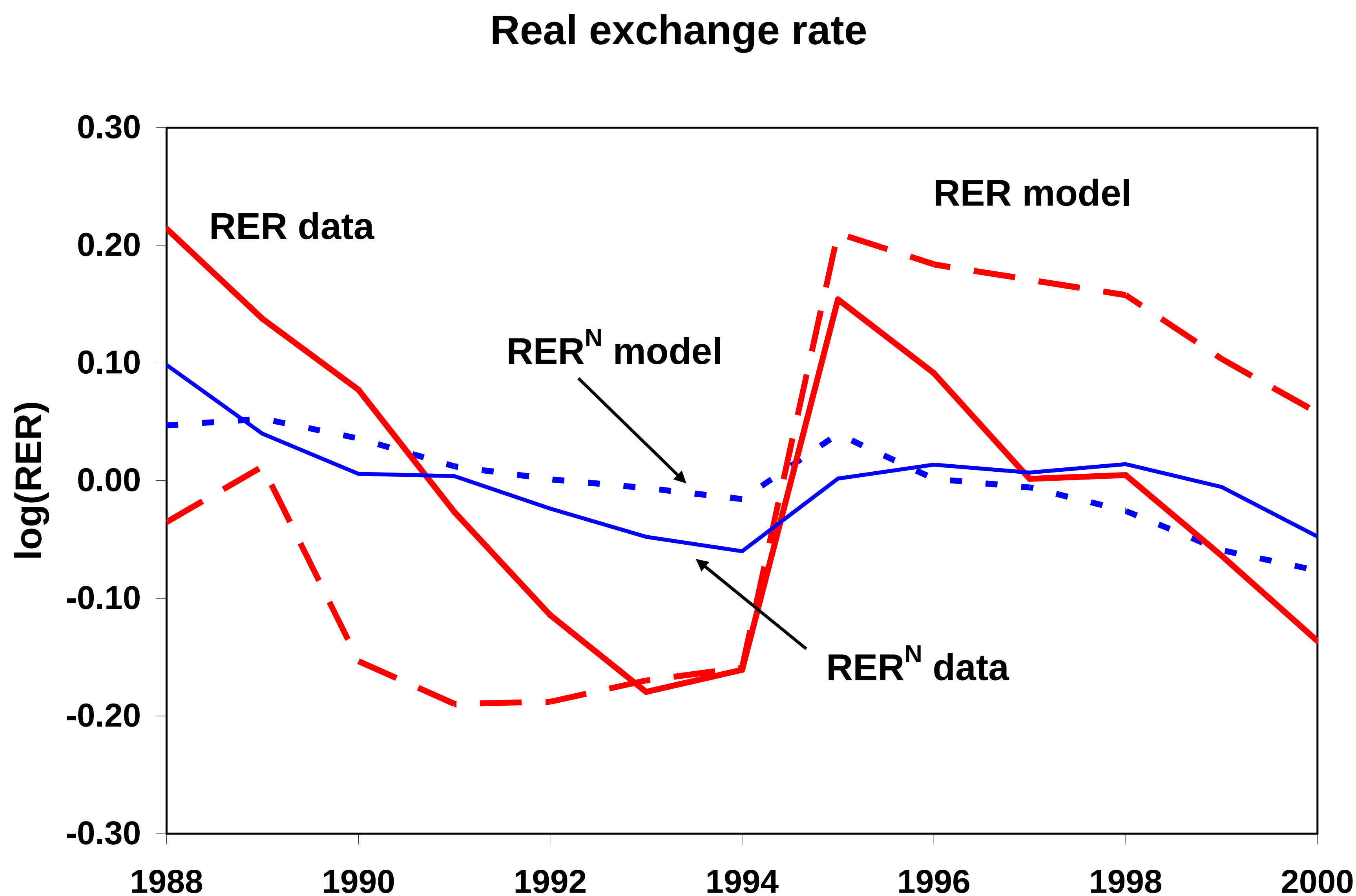

Model without sudden stop
Trade balance (left scale)
Capital-output ratio (right scale)
percent GDP
ratio
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
5.0
4.0
3.0
2.0
1.0
1988
1998
2008
2018
2028
2038
2048
2058

Sudden stop!

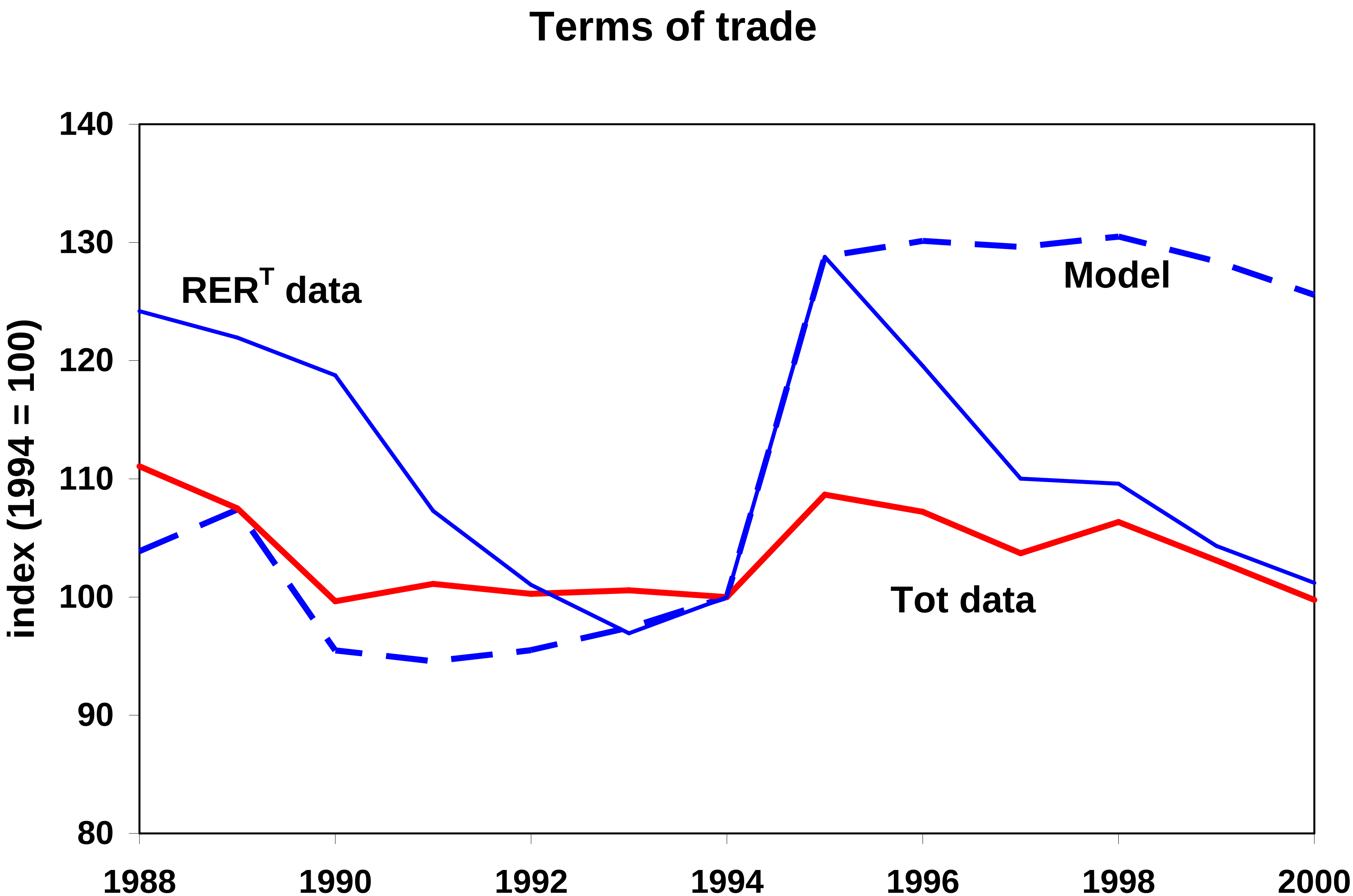
$$b_t = b_{t-1},\ t = 1995, 1996$$

- 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 $r_{1994}^{mex} = r^* + \sigma_{1994}^{mex}$


Trade balance
percent GDP
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
1988
1990
1992
1994
1996
1998
2000
Data
Model

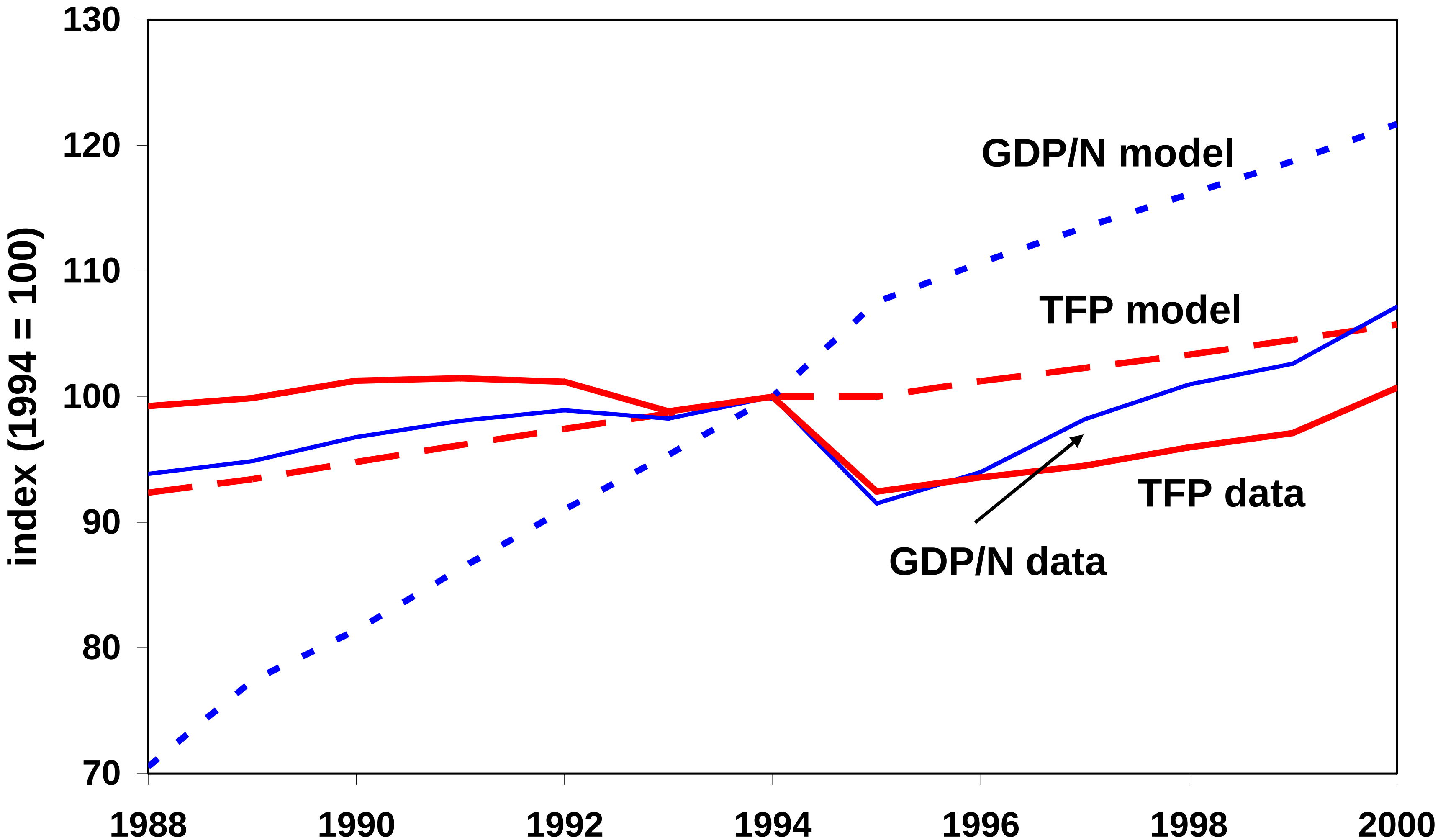


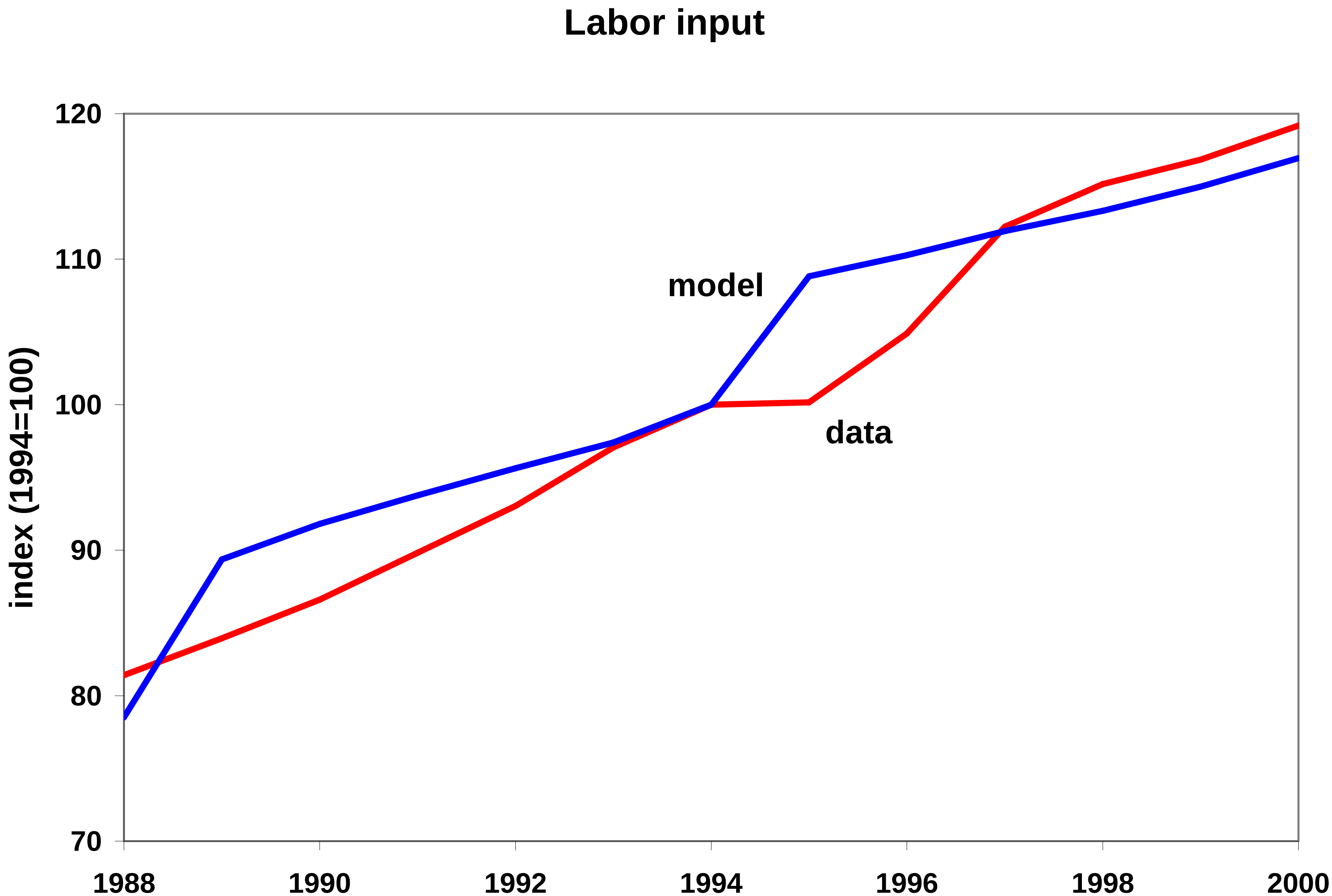
Real exchange rate
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
log(RER)
1988
1990
1992
1994
1996
1998
2000
RER data
RER model
RER^N model
RER^N data



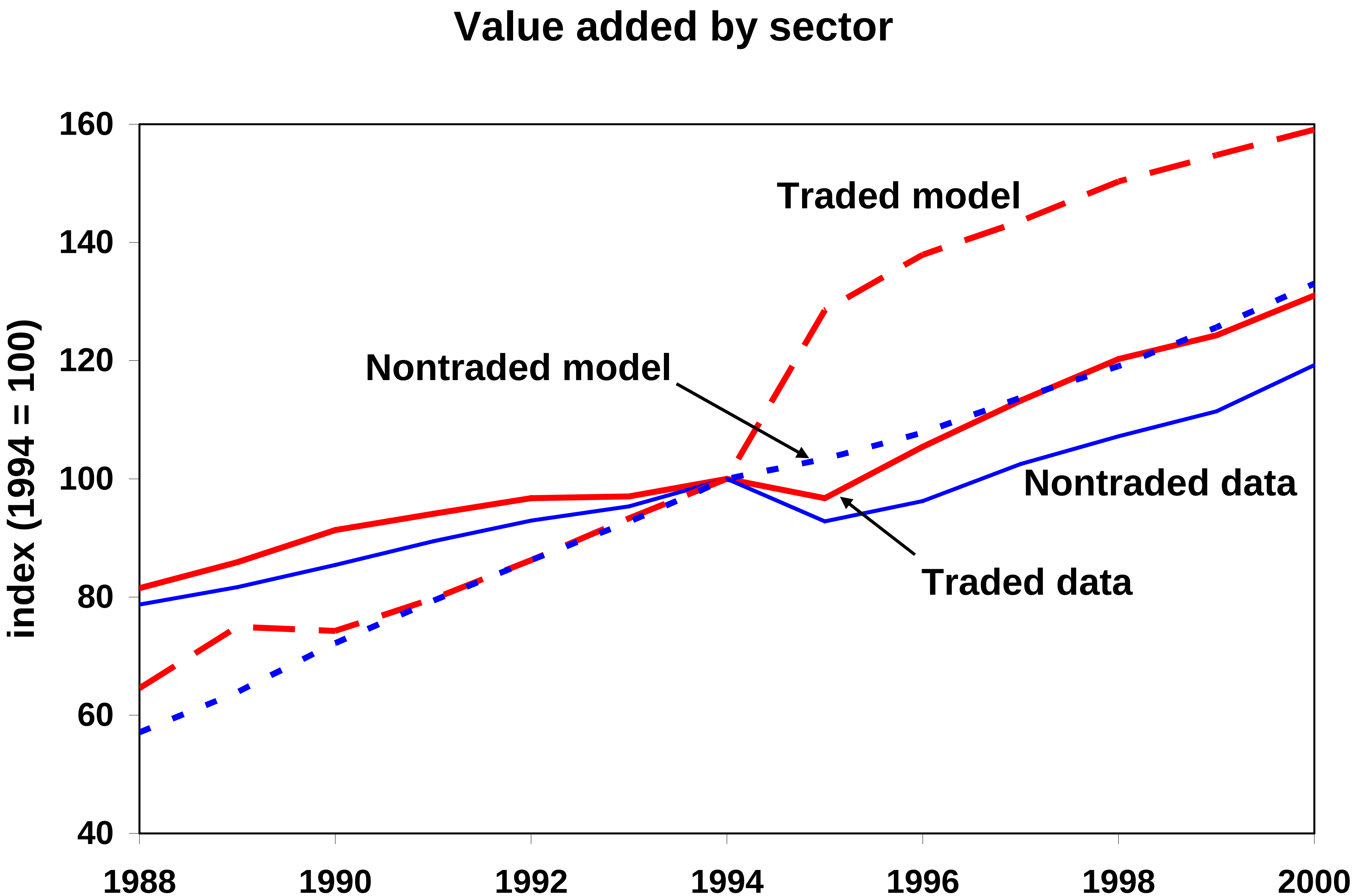
Terms of trade
index (1994 = 100)
140
130
120
110
100
90
80
1988
1990
1992
1994
1996
1998
2000
RER^T data
Model
Tot data

Output and TFP

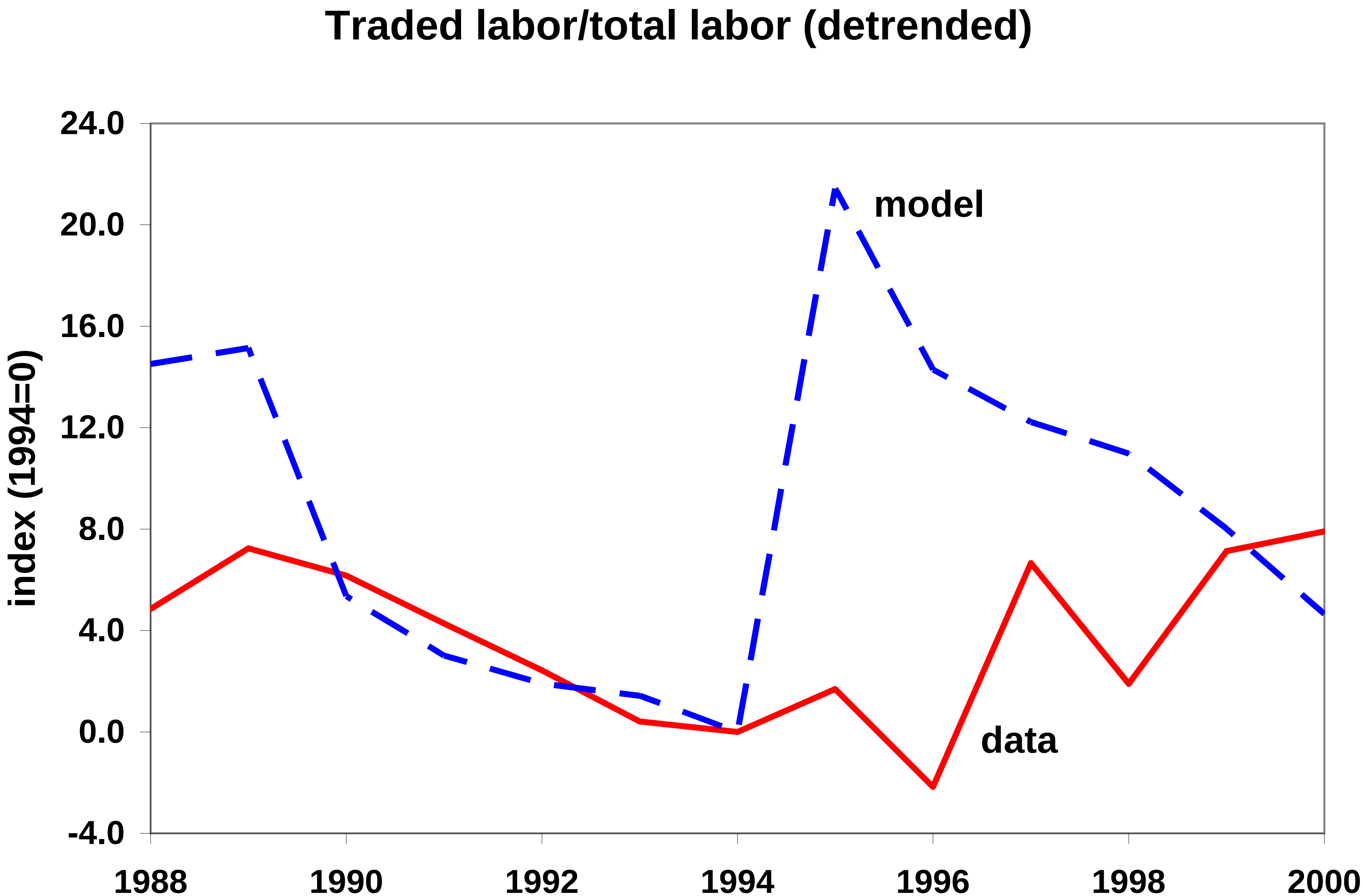




Labor input
index (1994=100)
120
110
100
90
80
70
model
data
1988
1990
1992
1994
1996
1998
2000



Value added by sector
index (1994 = 100)
160
140
120
100
80
60
40
1988
1990
1992
1994
1996
1998
2000
Traded model
Nontraded model
Nontraded data
Traded data


Traded labor/total labor (detrended)
index (1994=0)
24.0
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
1988
1990
1992
1994
1996
1998
2000
model
data

Alternative specifications

- no population growth
- no tariffs
- no interest rate premia
- exogenous TFP drop
- increase in foreign demand in 1995 to moderate deterioration in terms of trade
- labor market frictions
- variable capital utilization
- quasi-linear period utility
- perfect foresight — sudden stop is not a surprise

Variable capital utilization

- law of motion

$$k_{Dt+1} = \left(1-\delta(u_{Dt})\right)k_{Dt} + i_{Dt}$$

$$k_{Nt+1} = \left(1-\delta(u_{Nt})\right)k_{Nt} + i_{Nt}$$

where

$$\delta\left(u\right) = \bar{\delta} + \frac{\chi}{\omega}\left(u^{\omega} - 1\right)$$

- during crisis utilization of nontradable capital falls
- standard growth accounting:

$$\text{falling utilization} = \text{falling}\, TFP$$

TFP drop as exogenous

- robustness check: TFP drops **DO NOT** cause sudden stops

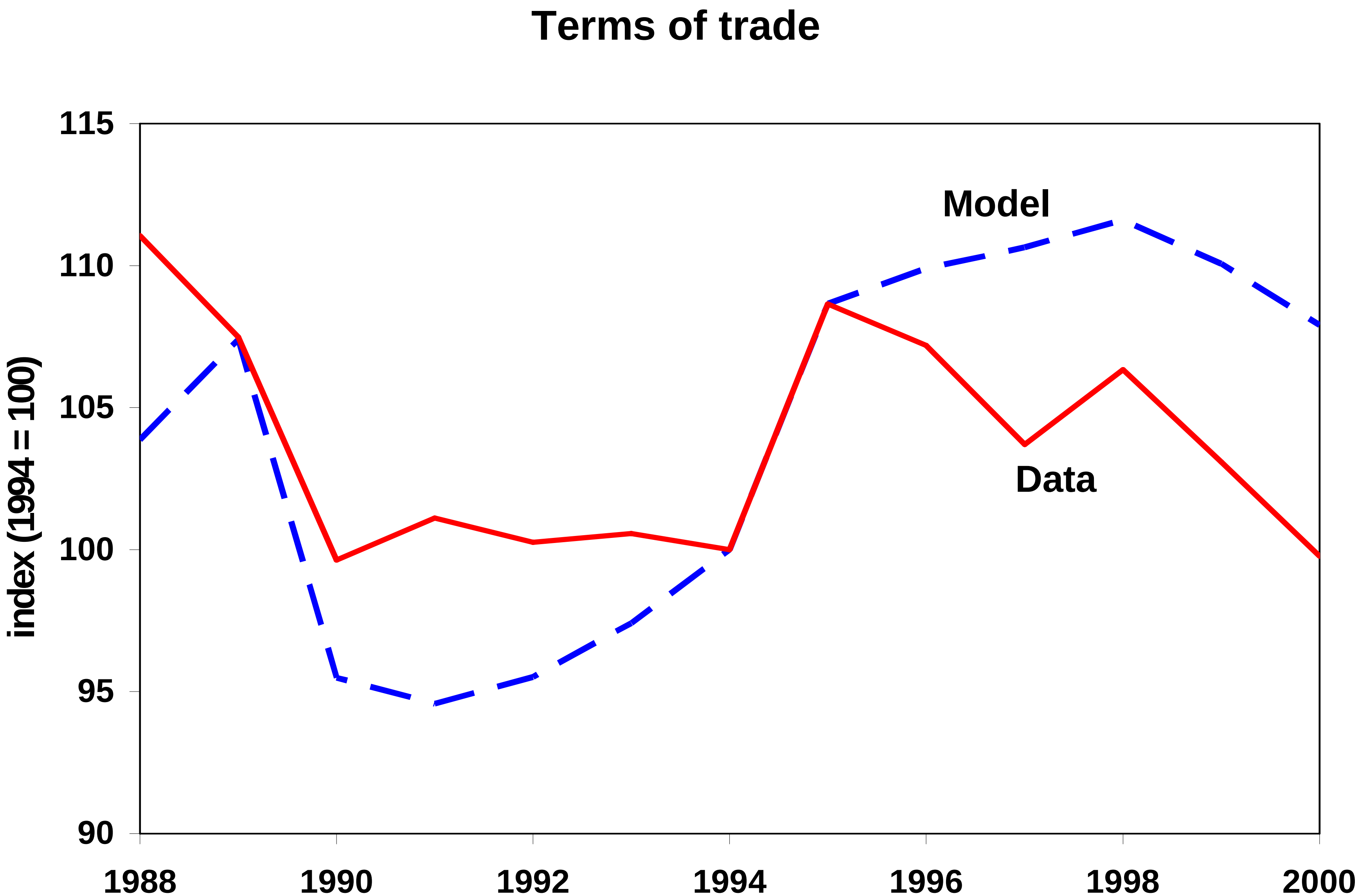
$$y_{D\tau} = \min\left[z_{TD\tau}/a_{TD},\ z_{ND\tau}/a_{ND},\ A_D k_{D\tau}^{\alpha_D} \left(\left(\nu_\tau \gamma\right)^{\tau} \ell_{D\tau} \right)^{1-\alpha_D} \right] - \Theta_D\left(\ell_{Dt-1}, \ell_{Dt}\right) \ell_{Dt-1}$$

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

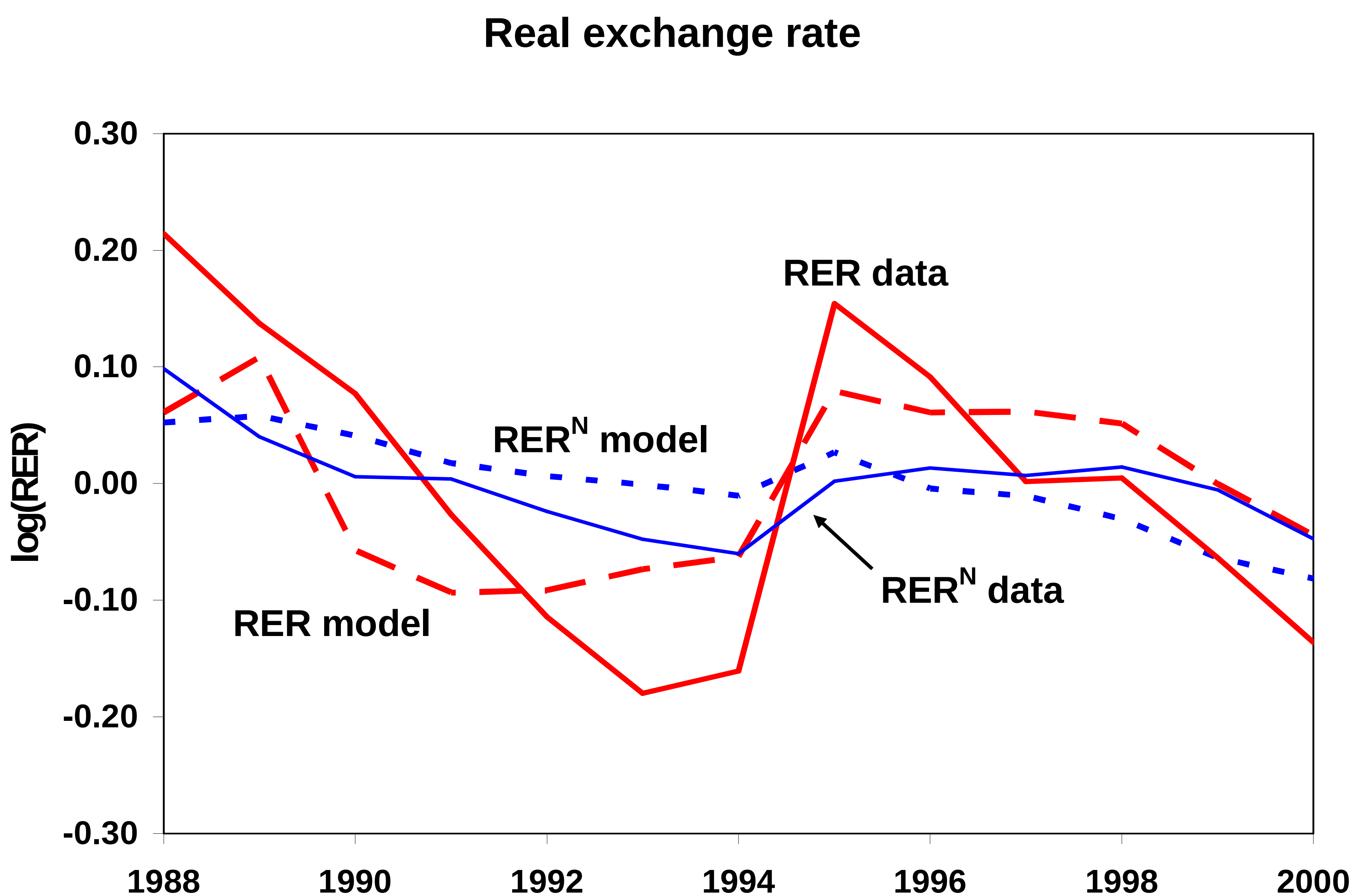
$$\nu_t = \begin{cases} 1.0 & t < 1995 \\ 0.89 & t \geq 1995 \end{cases}$$

- All else same

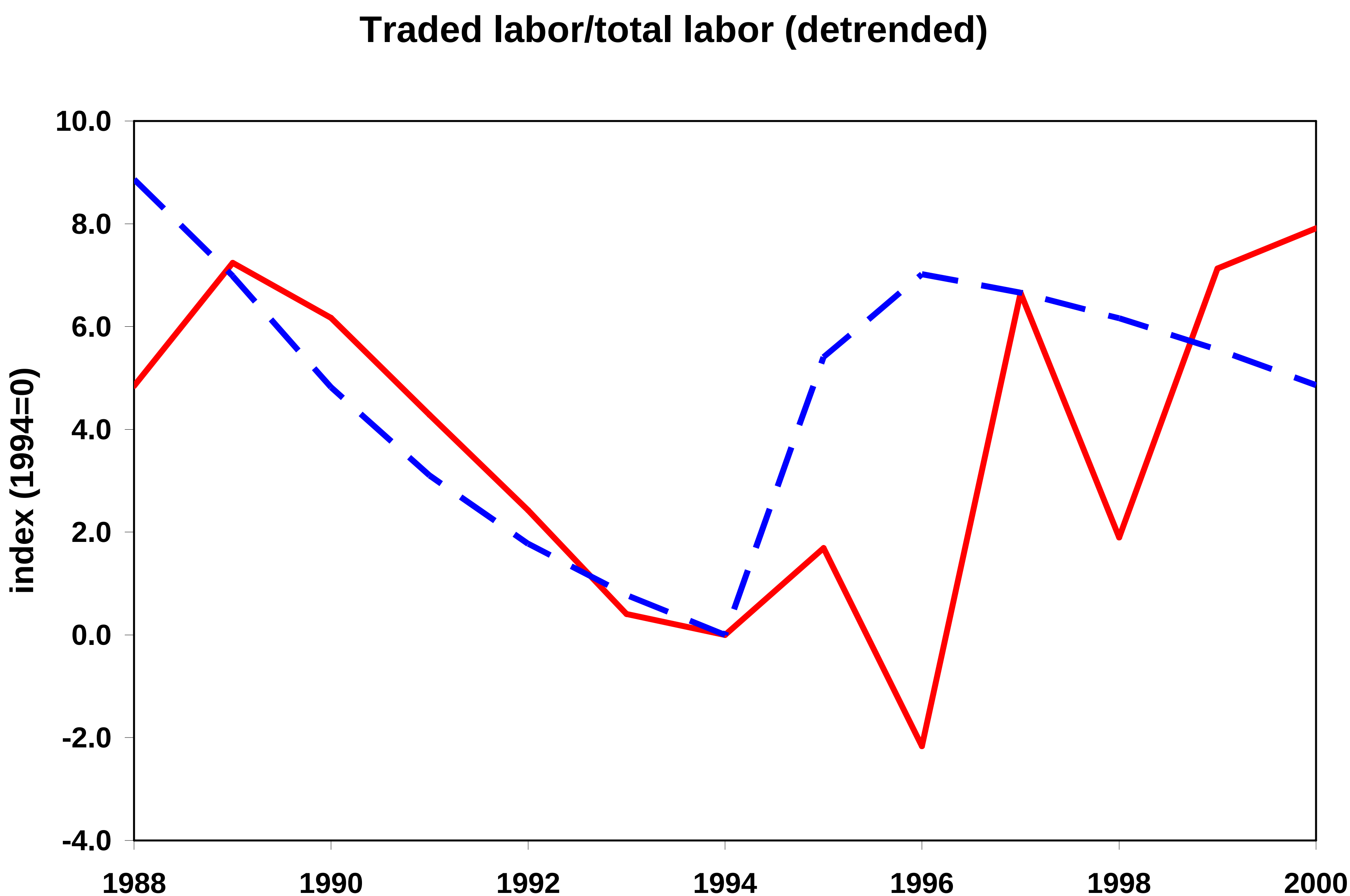
Increase in foreign demand in 1995 to moderate deterioration in terms of trade

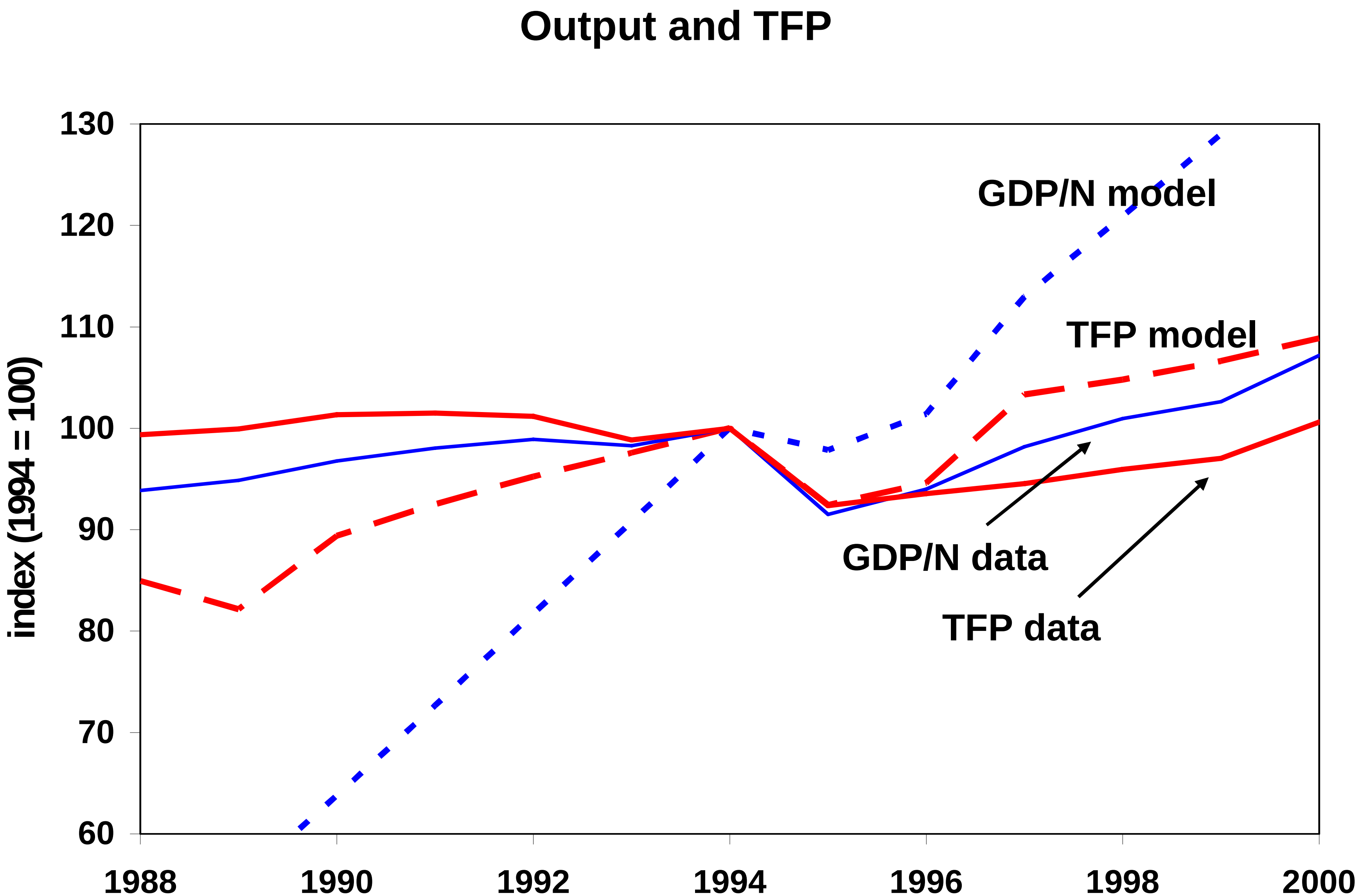


Terms of trade
Model
Data
index (1994 = 100)
115
110
105
100
95
90
1988
1990
1992
1994
1996
1998
2000

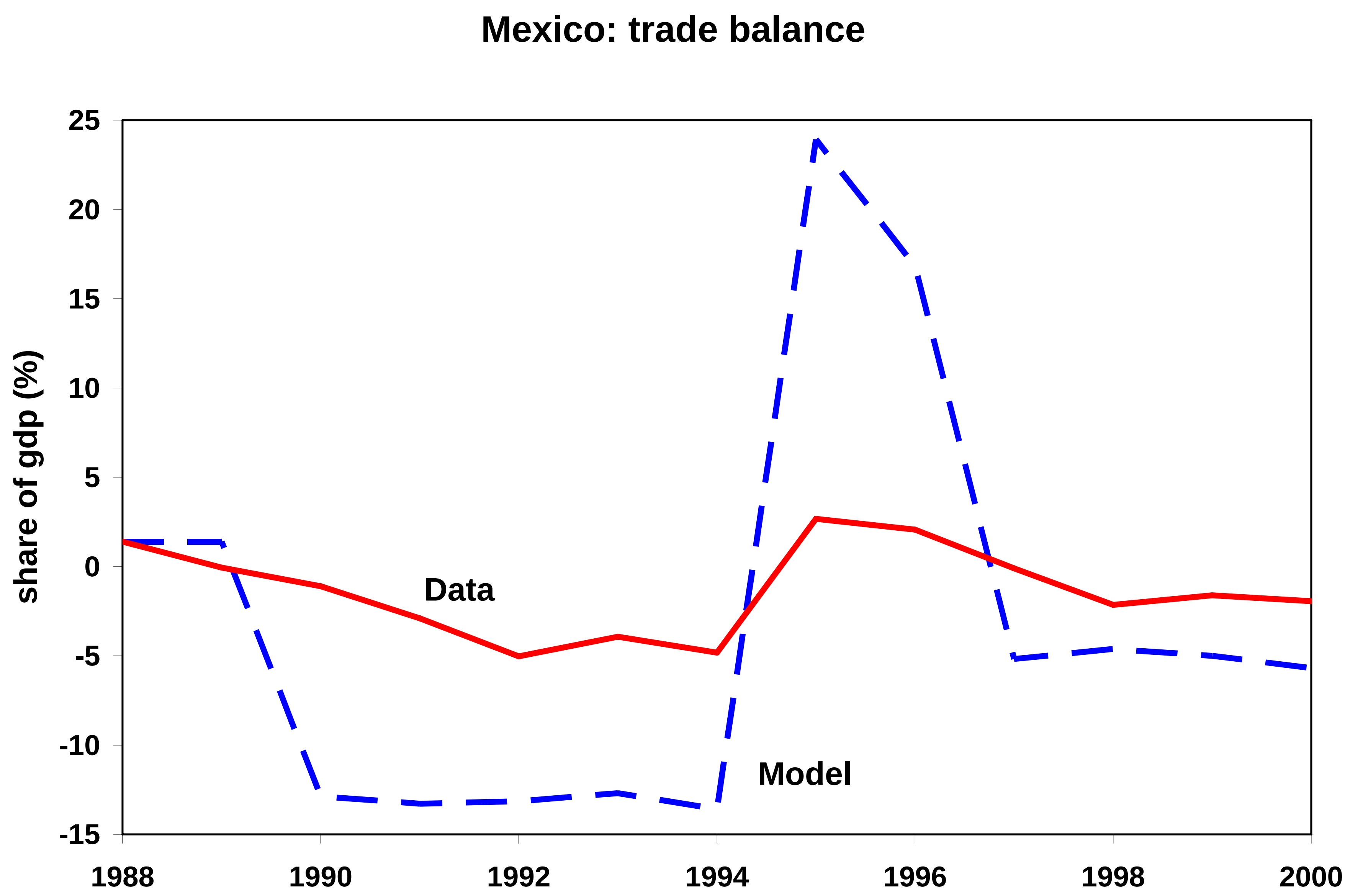

Real exchange rate
log(RER)
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
1988
1990
1992
1994
1996
1998
2000
RER data
RER^N model
RER^N data
RER model

Labor market frictions and variable capital utilization

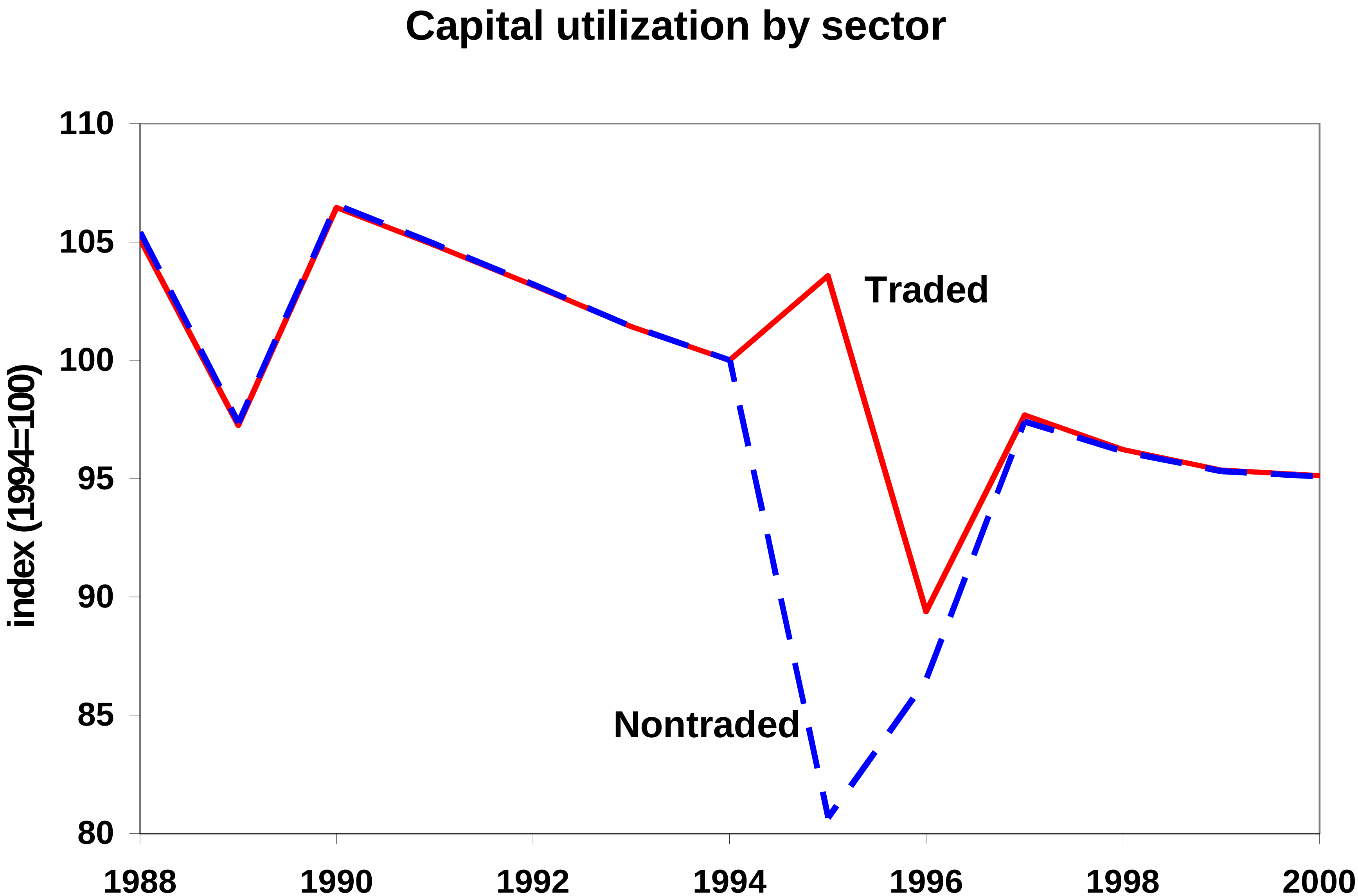

Traded labor/total labor (detrended)
index (1994=0)
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
1988
1990
1992
1994
1996
1998
2000



Output and TFP
index (1994 = 100)
130
120
110
100
90
80
70
60
1988
1990
1992
1994
1996
1998
2000
GDP/N model
TFP model
GDP/N data
TFP data

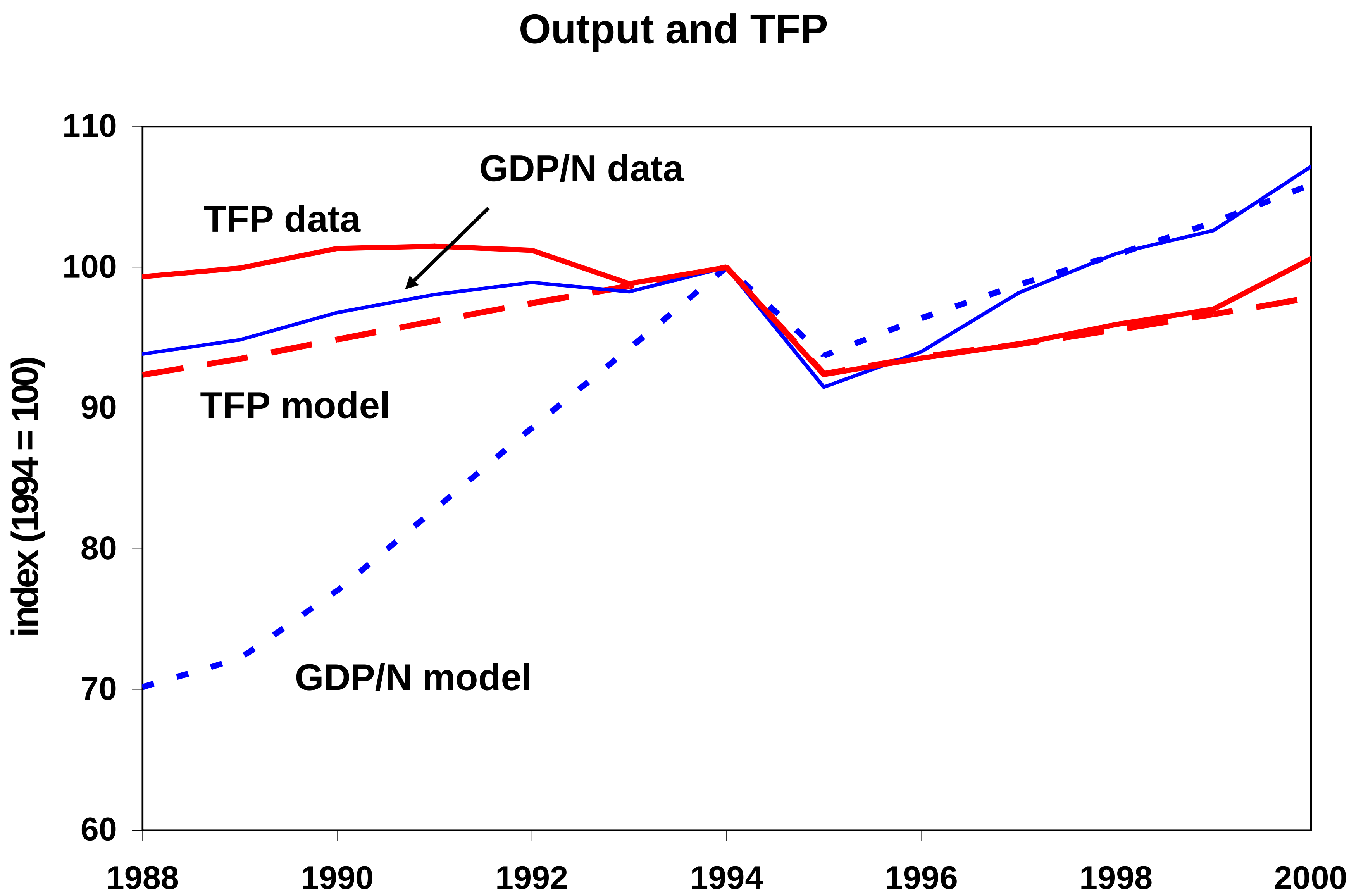


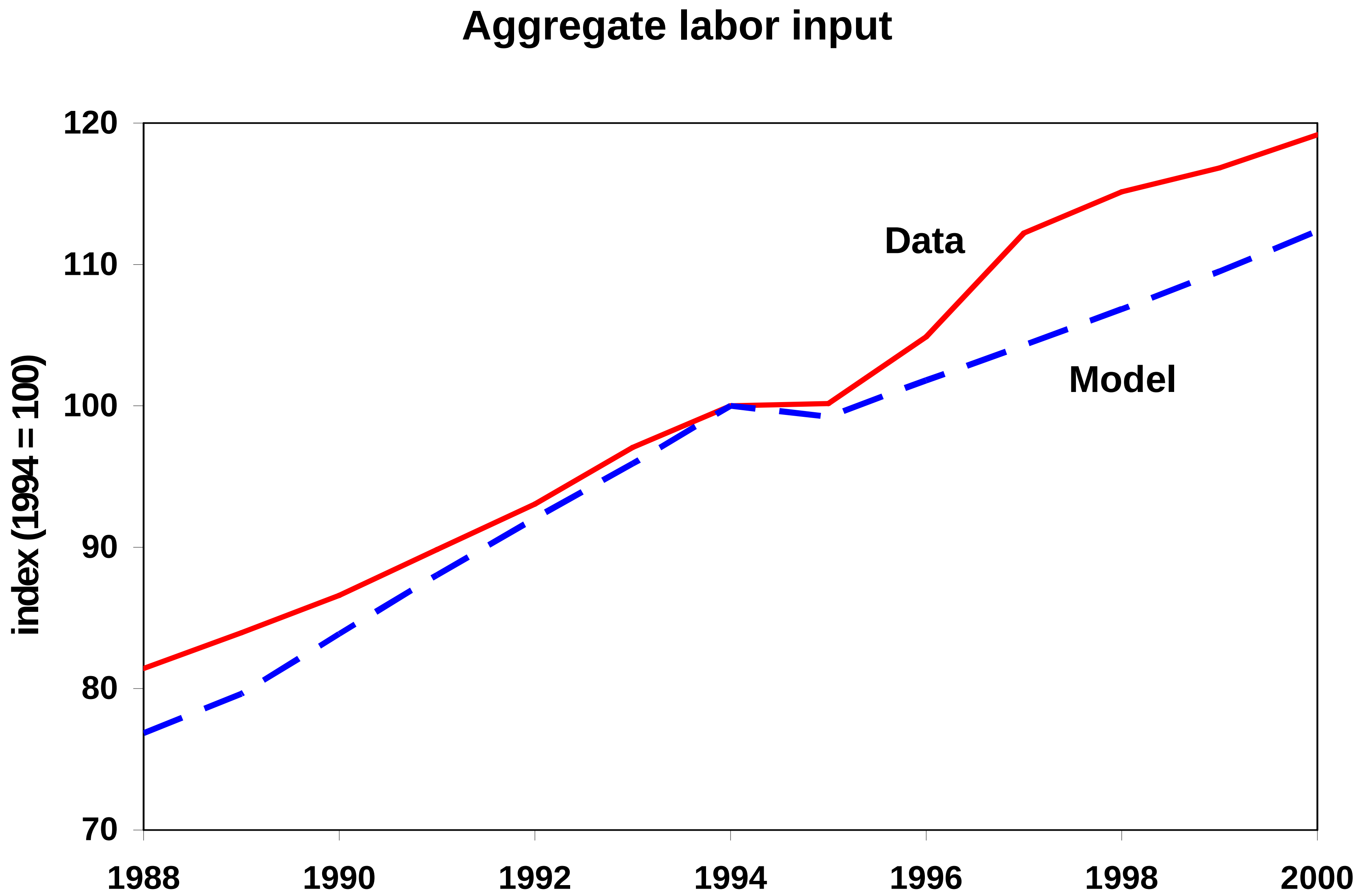
Mexico: trade balance
share of gdp (%)
25
20
15
10
5
0
-5
-10
-15
1988
1990
1992
1994
1996
1998
2000
Data
Model



Capital utilization by sector
index (1994=100)
110
105
100
95
90
85
80
1988
1990
1992
1994
1996
1998
2000
Traded
Nontraded

Exogenous TFP drop and quasi-linear period utility


Output and TFP
index (1994 = 100)
110
100
90
80
70
60
1988
1990
1992
1994
1996
1998
2000
GDP/N data
TFP data
TFP model
GDP/N model



Aggregate labor input
index (1994 = 100)
120
110
100
90
80
70
1988
1990
1992
1994
1996
1998
2000
Data
Model

Why doesn’t the deterioration in the terms of trade cause TFP and real GDP to fall?

Kehoe and Ruhl (2008), “Are Shocks to the Terms of Trade Shocks to Productivity?”

International trade as a production technology

Inputs are exports and outputs are imports.

$$p_t M_t = X_t \;\Rightarrow\; M_t = \frac{1}{p_t} X_t$$

A deterioration in the terms of trade (an increase in p_t) acts as a productivity shock.

International trade as a production technology

Inputs are exports and outputs are imports.

$$p_t M_t = X_t \;\Rightarrow\; M_t = \frac{1}{p_t} X_t$$

A deterioration in the terms of trade (an increase in p_t) acts as a productivity shock.

Or does it?