

An Evaluation of the Performance of Applied General Equilibrium Models of the Impact of NAFTA

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June 2002

Fifth Conference on Global Economic Analysis

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What Went Wrong in Modeling the Impact of the North American Free Trade Agreement?

Applied general equilibrium models were the only analytical game in town when it came to analyzing the impact of NAFTA in 1992-1993.

Typical sort of model: Static applied general equilibrium model with large number of industries and imperfect competition (Dixit-Stiglitz or Eastman-Stykolt) and finite number of firms in some industries. In some numerical experiments, new capital is placed in Mexico owned by consumers in the rest of North America to account for capital flows.

Examples:

Brown-Deardorff-Stern model of Canada, Mexico, and the United States

Cox-Harris model of Canada

Sobarzo model of Mexico

In 1993 Ross Perot said

The reason that most U.S. policymakers are so blind to the job shifting that will occur if NAFTA is ratified is that they rely on dozens of “reputable” academic studies that say it won’t happen. Yet these studies are based on unrealistic assumptions and flawed mathematical models...Let’s be clear about this: these studies certainly do not provide a basis on which Congress can make an informed decision about NAFTA.

Ross Perot with Pat Choate, ***Save Your Job, Save Our Country: Why NAFTA Must Be Stopped — Now!*** 1993.

In his comments, Timothy J. Kehoe observes that investment flows have generated a sharp increase in Mexican investment, GDP, and trade deficits. Policy makers have become concerned about the sustainability of this behavior, an issue not addressed by the CGE models. Kehoe also stresses that CGE remains at an early stage of development. He emphasizes the need for ex-post verification to achieve validation of these models. Kehoe also argues for more work on the impact of NAFTA on the behavior of financial intermediaries, policy credibility, demographic structures, and total factor productivity growth.

Nora Lustig, Barry P. Bosworth, and Robert Z. Lawrence, editors, ***North American Free Trade: Assessing the Impact***, 1992.

Research Agenda:

- Compare results of numerical experiments of models with data.
- Determine what shocks — besides NAFTA policies — were important.
- Construct a simple applied general equilibrium model and perform experiments with alternative specifications to determine what was wrong with the 1992-1993 models.

Applied GE Models Can Do a Good Job!

Spain 1985-1986: 1985–1986 Kehoe-Manresa-Noyola-Polo-Sancho-Serra MEGA model of the Spanish economy: A Shoven-Whalley type model with perfect competition, modified to allow government and trade deficits and unemployment (Kehoe-Serra). Spain's entry into the European Community in 1986 was accompanied by a fiscal reform that introduced a value-added tax (VAT) on consumption to replace a complex range of indirect taxes, including a turnover tax applied at every stage of the production process. What would happen to tax revenues? Trade reform was of secondary importance.

Canada-U.S.: Fox (1999).

Other changes besides policy changes are important!

Changes in Consumer Prices in the Spanish Model (Percent)

sector	data 1985-1986	model policy only	model shocks only	model policy&shocks
food and nonalcoholic beverages	1.8	-2.3	4.0	1.7
tobacco and alcoholic beverages	3.9	2.5	3.1	5.8
clothing	2.1	5.6	0.9	6.6
housing	-3.3	-2.2	-2.7	-4.8
household articles	0.1	2.2	0.7	2.9
medical services	-0.7	-4.8	0.6	-4.2
transportation	-4.0	2.6	-8.8	-6.2
recreation	-1.4	-1.3	1.5	0.1
other services	2.9	1.1	1.7	2.8
weighted correlation with data		-0.08	0.87	0.94
variance decomposition of change		0.50	0.54	0.53

Measures of Accuracy of Model Results

1. Weighted correlation coefficient.
2. Variance decomposition of the (weighted) variance of the changes in the data:

$$\text{vardec}(y^{\text{data}}, y^{\text{model}}) = \frac{\text{var}(y^{\text{model}})}{\text{var}(y^{\text{model}}) + \text{var}(y^{\text{data}} - y^{\text{model}})}$$

Changes in Value of Gross Output/GDP in the Spanish Model (Percent)

sector	data 1985-1986	model policy only	model shocks only	model policy&shocks
agriculture	-0.4	-1.1	8.3	6.9
energy	-20.3	-3.5	-29.4	-32.0
basic industry	-9.0	1.6	-1.8	-0.1
machinery	3.7	3.8	1.0	5.0
automobile industry	1.1	3.9	4.7	8.6
food products	-1.8	-2.4	4.7	2.1
other manufacturing	0.5	-1.7	2.3	0.5
construction	5.7	8.5	1.4	10.3
commerce	6.6	-3.6	4.4	0.4
transportation	-18.4	-1.5	1.0	-0.7
services	8.7	-1.1	5.8	4.5
government services	7.6	3.4	0.9	4.3
weighted correlation with data		0.01	0.80	0.72
variance decomposition of change		0.09	0.67	0.63

Changes in Trade/GDP in the Spanish Model (Percent)

	data	model	model	model
direction of exports	1985-1986	policy only	shocks only	policy&shocks
Spain to rest of E.C.	-6.7	-3.2	-4.9	-7.8
Spain to rest of world	-33.2	-3.6	-6.1	-9.3
rest of E.C. to Spain	14.7	4.4	-3.9	0.6
rest of world to Spain	-34.1	-1.8	-16.8	-9.3
weighted correlation with data		0.83	0.75	0.85
variance decomposition of change		0.07	0.54	0.37

Changes in Composition of GDP in the Spanish Model (Percent of GDP)

variable	data 1985-1986	model policy only	model shocks only	model policy&shocks
wages and salaries	-0.53	-0.87	-0.02	-0.91
business income	-1.27	-1.63	0.45	-1.24
net indirect taxes and tariffs	1.80	2.50	-0.42	2.15
correlation with data		0.998	-0.94	0.99
variance decomposition of change		0.93	0.04	0.96
private consumption	-0.81	-1.23	-0.51	-1.78
private investment	1.09	1.81	-0.58	1.32
government consumption	-0.02	-0.06	-0.38	-0.44
government investment	-0.06	-0.06	-0.07	-0.13
exports	-3.40	-0.42	-0.69	-1.07
-imports	3.20	-0.03	2.23	2.10
correlation with data		0.40	0.77	0.83
variance decomposition of change		0.20	0.35	0.58

Public Finances in the Spanish Model (Percent of GDP)

variable	data 1985-1986	model policy only	model shocks only	model policy&shocks
indirect taxes and subsidies	2.38	3.32	-0.38	2.98
tariffs	-0.58	-0.82	-0.04	-0.83
social security payments	0.04	-0.19	-0.03	-0.22
direct taxes and transfers	-0.84	-0.66	0.93	0.26
government capital income	-0.13	-0.06	0.02	-0.04
total government revenue	0.87	1.60	0.48	2.14
correlation with data		0.99	-0.70	0.92
variance decomposition of change		0.93	0.08	0.86

Models of NAFTA Did Not Do a Good Job!

Ex-post evaluations of the performance of applied GE models are essential if policy makers are to have confidence in the results produced by this sort of model.

Just as importantly, they help make applied GE analysis a scientific discipline in which there are well-defined puzzles and clear successes and failures for alternative hypotheses.

Changes in Trade/GDP in Brown-Deardorff-Stern Model (Percent)

variable	data 1988-1999	model
Canada exports	52.9	5.0
Canadian imports	57.7	5.0
Mexican exports	141.2	48.9
Mexican imports	50.9	41.2
U.S. exports	55.5	3.0
U.S. imports	98.5	2.4
weighted correlation with data		0.14
variance decomposition of change		0.0003

Changes in Canadian Trade/GDP in Cox-Harris Model (Percent)

variable	data 1988-2000	model
total trade	61.8	10.0
trade with United States	89.6	20.0
trade with Mexico	385.1	52.3
weighted correlation with data		0.96
variance decomposition of change		0.06

Changes in Canadian Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Mexico		exports to U.S.	
	1988-1999	model	1988-1999	model
agriculture	n.a.	3.1	75.2	3.4
mining and quarrying	n.a.	-0.3	64.4	0.4
food	n.a.	2.2	174.9	8.9
textiles	206.2	-0.9	487.4	15.3
clothing	664.8	1.3	351.7	45.3
leather products	852.2	1.4	107.2	11.3
footwear	0.0	3.7	185.2	28.3
wood products	-42.4	4.7	214.6	0.1
furniture and fixtures	317.7	2.7	497.3	12.5
paper products	133.9	-4.3	36.3	-1.8
printing and publishing	n.a.	-2.0	154.3	-1.6
chemicals	19.7	-7.8	155.1	-3.1
petroleum and products	626.2	-8.5	39.6	0.5
rubber products	62.2	-1.0	325.9	9.5
nonmetal mineral products	n.a.	-1.8	39.6	1.2
glass products	n.a.	-2.2	325.9	30.4
iron and steel	-72.5	-15.0	61.1	12.9
nonferrous metals	567.1	-64.7	66.8	18.5
metal products	194.0	-10.0	164.5	15.2
nonelectrical machinery	186.0	-8.9	154.2	3.3
electrical products	159.9	-26.2	321.2	14.5
transportation equipment	322.5	-4.2	121.5	10.7
miscellaneous manufactures	n.a.	-12.1	225.3	-2.1
weighted correlation with data		-0.27		0.92
variance decomposition of change		0.003		0.01

Changes in Mexican Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Canada		exports to U.S.	
	1988-1999	model	1988-1999	model
agriculture	n.a.	-4.1	-17.2	2.5
mining and quarrying	n.a.	27.3	-24.1	26.9
food	n.a.	10.8	14.6	7.5
textiles	10.0	21.6	547.9	11.8
clothing	878.5	19.2	2161.0	18.6
leather products	400.3	36.2	266.0	11.7
footwear	109.0	38.6	183.7	4.6
wood products	126.1	15.0	40.6	-2.7
furniture and fixtures	1742.7	36.2	1833.5	7.6
paper products	153.9	32.9	12.0	13.9
printing and publishing	n.a.	15.0	653.1	3.9
chemicals	9.0	36.0	40.9	17.0
petroleum and products	116.8	32.9	96.6	34.1
rubber products	770.2	-6.7	181.1	-5.3
nonmetal mineral products	n.a.	5.7	96.6	3.7
glass products	n.a.	13.3	181.1	32.3
iron and steel	30.9	19.4	41.3	30.8
nonferrous metals	-32.5	138.1	-40.2	156.5
metal products	179.8	41.9	470.4	26.8
nonelectrical machinery	82.9	17.3	566.5	18.5
electrical products	203.4	137.3	3214.0	178.0
transportation equipment	286.0	3.3	216.5	6.2
miscellaneous manufactures	n.a.	61.1	942.5	43.2
weighted correlation with data		0.54		0.29
variance decomposition of change		0.14		0.01

Changes in U. S. Exports/GDP in the Brown-Deardorff-Stern Model (Percent)

sector	exports to Canada		exports to Mexico	
	1988-1999	model	1988-1999	model
agriculture	151.1	5.1	24.4	7.9
mining and quarrying	-16.4	1.0	234.2	0.5
food	47.6	12.7	71.5	13.0
textiles	45.3	44.0	1327.1	18.6
clothing	147.7	56.7	1323.1	50.3
leather products	-37.1	7.9	999.6	15.5
footwear	-2.4	45.7	223.1	35.4
wood products	0.3	6.7	276.0	7.0
furniture and fixtures	181.1	35.6	330.5	18.6
paper products	57.0	18.9	160.8	-3.9
printing and publishing	0.8	3.9	240.0	-1.1
chemicals	53.8	21.8	160.8	-8.4
petroleum and products	7.3	0.8	571.8	-7.4
rubber products	57.5	19.1	660.0	12.8
nonmetal mineral products	7.3	11.9	571.8	0.8
glass products	57.5	4.4	660.0	42.3
iron and steel	41.2	11.6	115.7	-2.8
nonferrous metals	-1.0	-6.7	223.3	-55.1
metal products	38.5	18.2	537.5	5.4
nonelectrical machinery	-5.3	9.9	240.9	-2.9
electrical products	38.5	14.9	1191.7	-10.9
transportation equipment	-4.2	-4.6	586.8	9.9
miscellaneous manufactures	45.1	11.5	352.1	-9.4
weighted correlation with data		0.58		-0.29
variance decomposition of change		0.26		0.001

Changes in Canadian Trade/GDP in the Cox-Harris Model (Percent)

sector	total exports		total imports	
	1988-2000	model	1988-2000	model
agriculture	n.a.	-4.3	n.a.	6.9
forestry	n.a.	-11.3	n.a.	7.1
fishing	n.a.	-5.2	n.a.	9.1
mining	n.a.	-7.1	n.a.	3.9
food, beverages, and tobacco	n.a.	15.2	n.a.	3.6
rubber and plastics	130.3	24.6	88.2	13.8
textiles and leather	73.5	108.5	19.6	18.0
wood and paper	20.0	7.4	78.3	7.3
steel and metal products	23.6	18.9	60.9	9.5
transportation equipment	66.3	3.2	19.3	2.6
machinery and appliances	148.1	54.3	75.2	11.2
nonmetallic minerals	n.a.	31.8	n.a.	7.3
refineries	n.a.	-2.6	n.a.	1.5
chemicals and misc. manufactures	n.a.	28.2	n.a.	10.3
weighted correlation with data		0.65		0.99
variance decomposition of change		0.11		0.03

Changes in Mexican Trade/GDP in the Sobarzo Model (Percent)

sector	exports to rest of North America		imports from rest of North America	
	1988-2000	model	1988-2000	model
agriculture	n.a	-11.1	n.a	3.4
mining	n.a	-17.0	n.a	10.6
petroleum	12.3	-19.5	185.6	-6.8
food	n.a	-6.9	n.a	-5.0
beverages	46.0	5.2	170.7	-1.8
tobacco	-71.5	2.8	138.9	-11.6
textiles	154.9	1.9	229.9	-1.2
wearing apparel	314.1	30.0	129.4	4.5
leather	n.a.	12.4	n.a	-0.4
wood	n.a.	-8.4	n.a	11.7
paper	n.a.	-7.9	n.a	-4.7
chemicals	-32.4	-4.4	24.4	-2.7
rubber	59.6	12.8	24.9	-0.1
nonmetallic minerals	-1.9	-6.2	123.6	10.9
iron and steel	35.0	-4.9	8.5	17.7
nonferrous metals	-52.5	-9.8	47.3	9.8
metal products	102.8	-4.4	213.0	9.5
nonelectrical machinery	104.8	-7.4	49.9	20.7
electrical machinery	57.3	1.0	125.1	9.6
transportation equipment	260.4	-5.0	77.9	11.2
other manufactures	n.a.	-4.5	n.a	4.2
weighted correlation with data		-0.25	0.64	
variance decomposition of change		0.01	0.07	

Sectoral Detail: What Drives Increases In Trade?

Kehoe and Ruhl (2002)

Data:

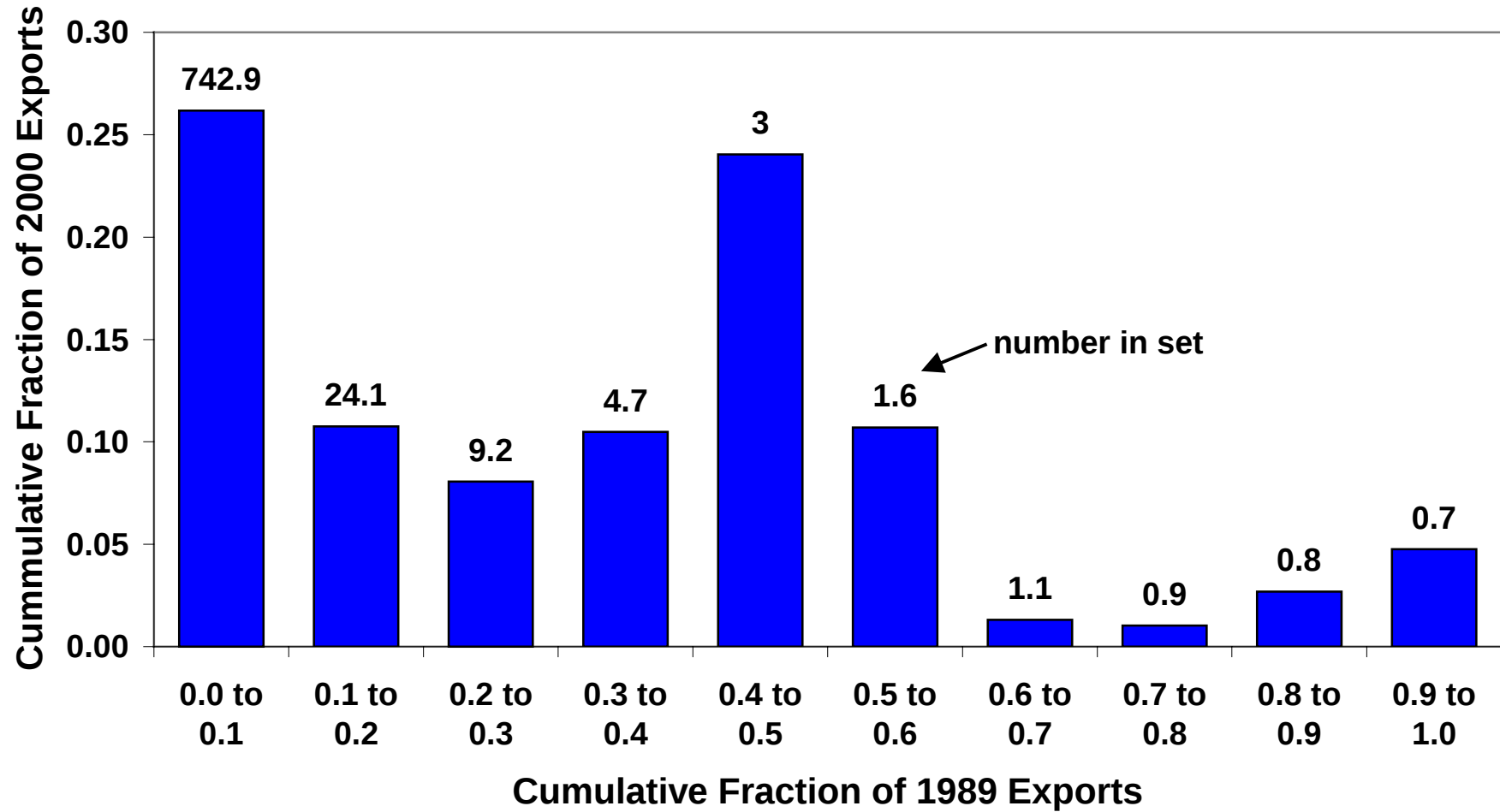
four-digit SITC bilateral trade data (789 categories — source: OECD).

Exercise:

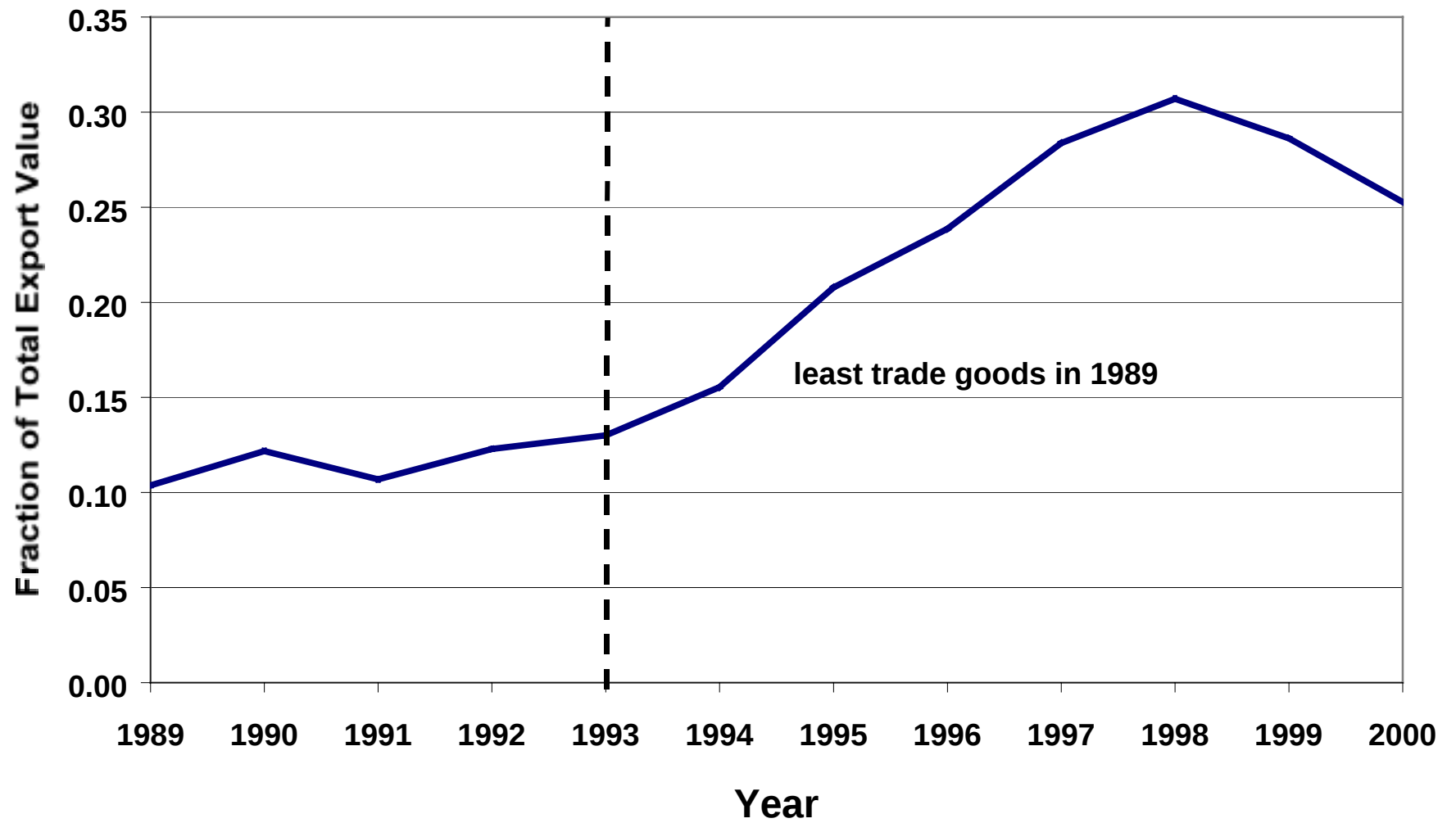
- rank categories in order of base year exports.
- form sets of categories by cumulating exports — the first 2 categories account for 10 percent of exports, for example; the next 4 categories account for 10 percent of exports; and so on.
- calculate the fraction of exports in subsequent years accounted for by each set of categories.

Exports: Mexico to Canada 1989-2000

By Sets of Categories Based on Export Size



Exports: Mexico to Canada



Exports: Mexico to U.S.



Ricardian model with a continuum of goods $x \in [0,1]$

production technologies $y(x) = \ell(x)/a(x)$, $y^*(x) = \ell^*(x)/a^*(x)$

ad valorem tariffs τ, τ^*

$$(1 + \tau^*)wa(x) < w^*a^*(x) \Leftrightarrow \frac{a(x)}{a^*(x)} < \frac{w^*}{(1 + \tau^*)w}$$

$\Rightarrow$ home country produces good and exports it to the foreign country.

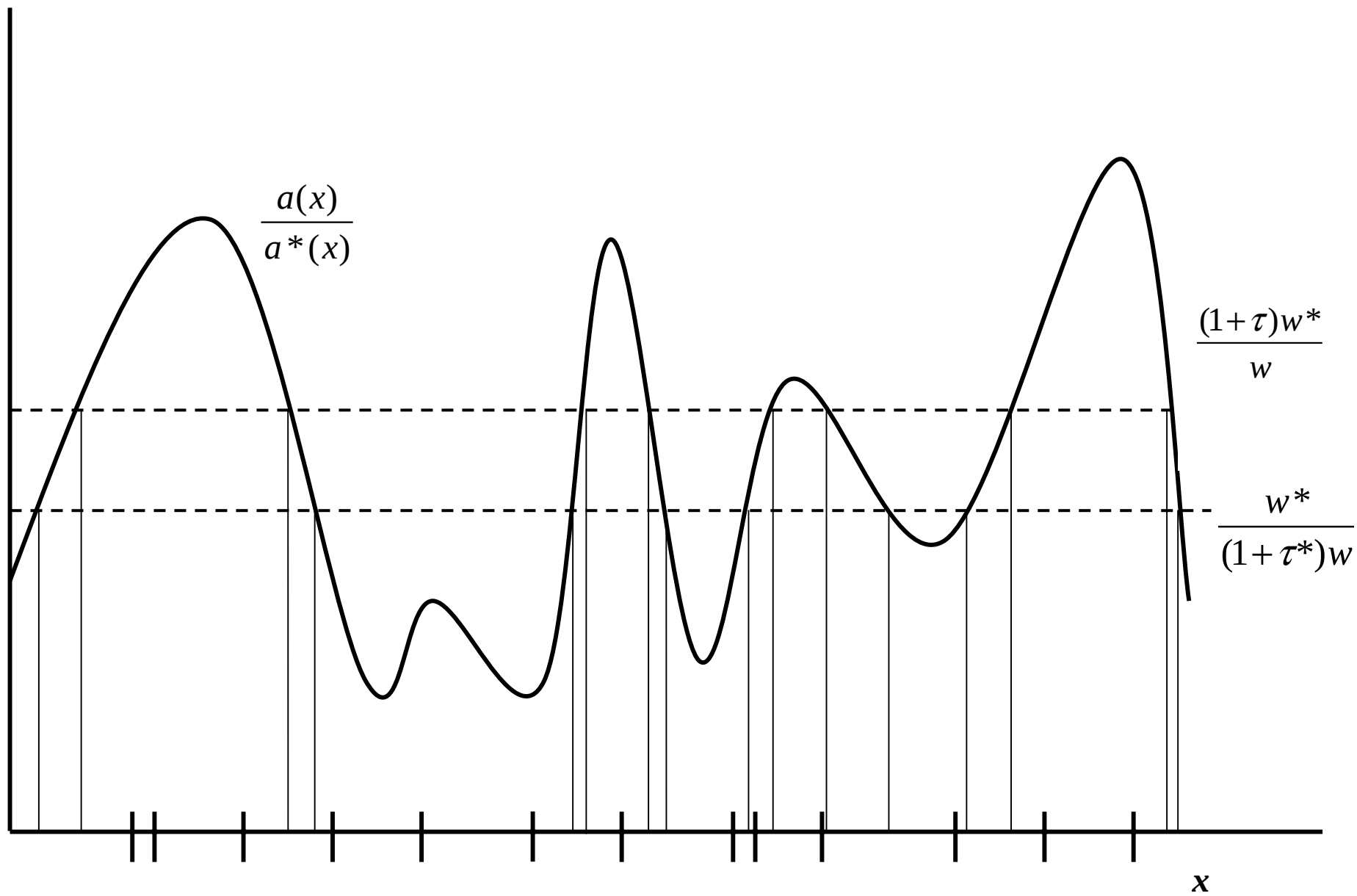
$$\frac{a(x)}{a^*(x)} > \frac{(1 + \tau)w^*}{w}$$

$\Rightarrow$ foreign country produces good and exports it to the home country.

$$\frac{(1 + \tau)w^*}{w} < \frac{a(x)}{a^*(x)} < \frac{w^*}{(1 + \tau^*)w}$$

$\Rightarrow$ good is not traded.

Lowering tariffs can generate trade in previously nontraded goods.



Big Question: What Drives Changes in Productivity?

one-sector growth model

$$\text{maximize } \sum_{t=1988}^{\infty} \beta^t [\gamma \log C_t + (1-\gamma) \log(\bar{h}N_t - L_t)]$$

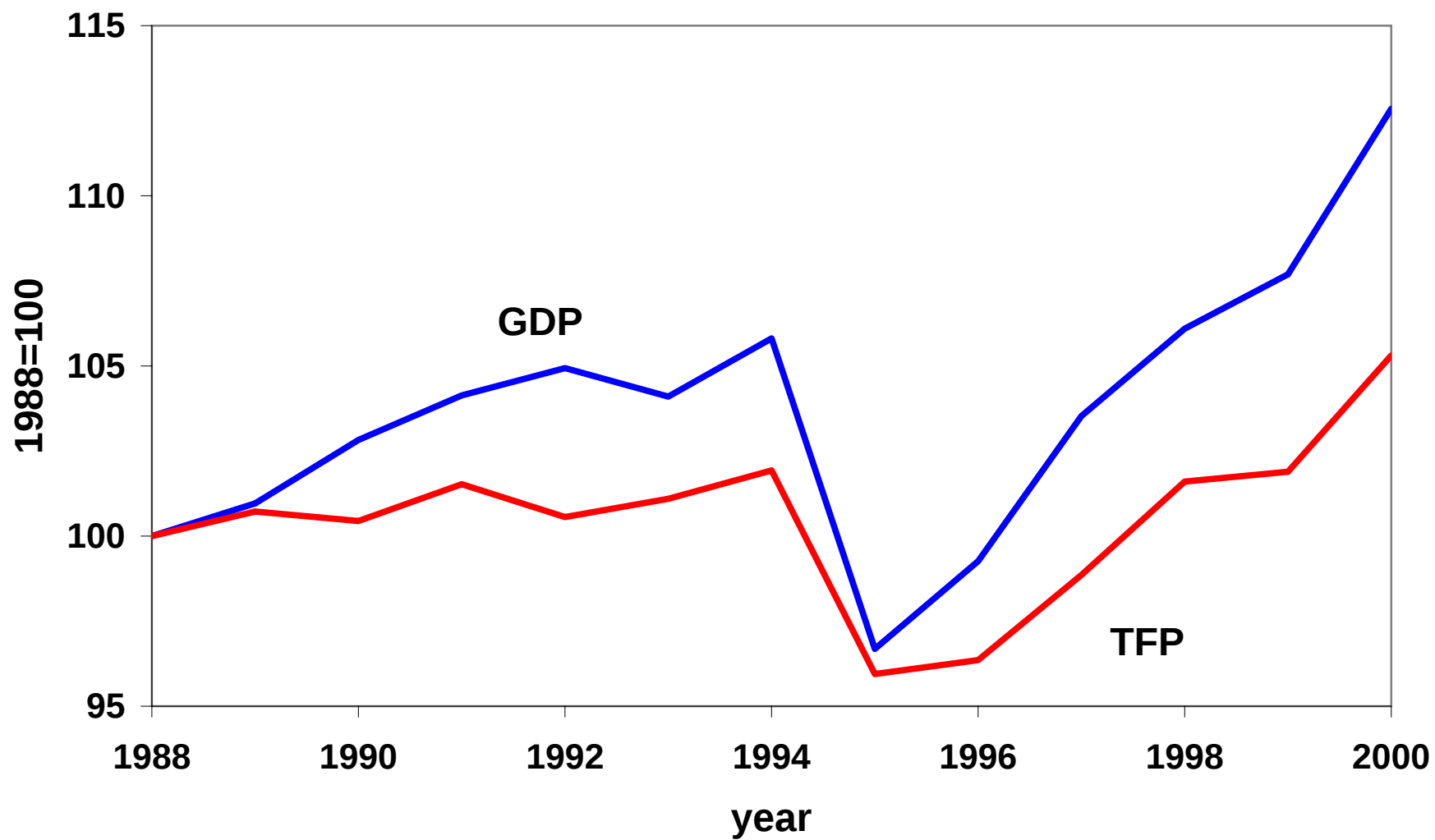
$$\text{subject to } C_t + K_{t+1} - K_t = w_t L_t + (1-\tau_t)(r_t - \delta)K_t + T_t - X_t$$

feasibility constraint

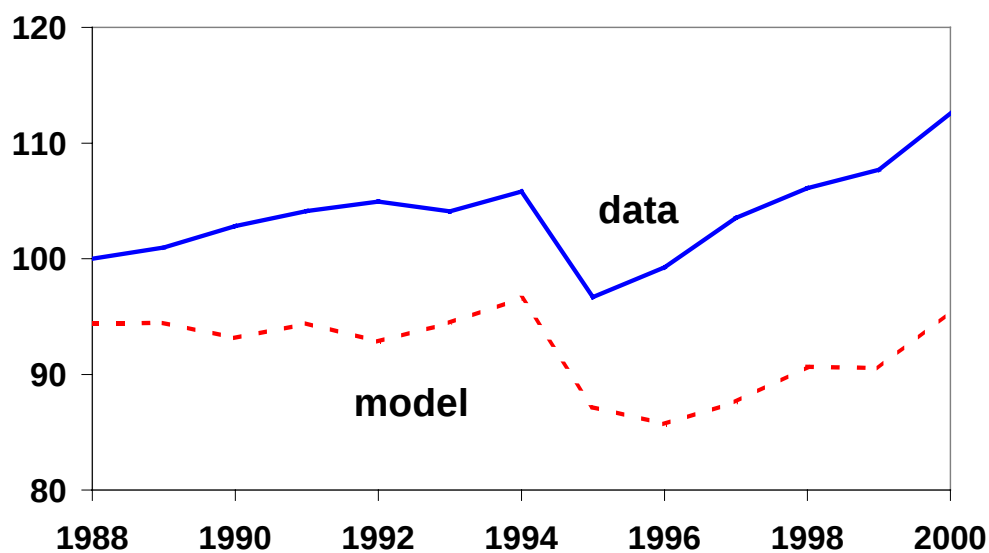
$$C_t + K_{t+1} - (1-\delta)K_t + X_t = A_t K_t^\alpha L_t^{1-\alpha}.$$

A_t and X_t are treated as exogenous.

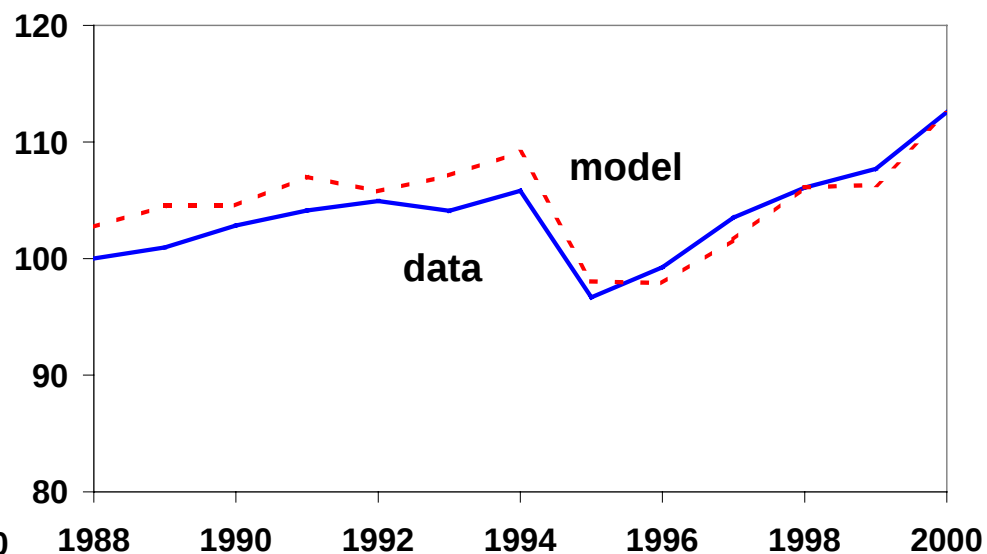
Real GDP per Working Age (15-64) person and TFP in Mexico



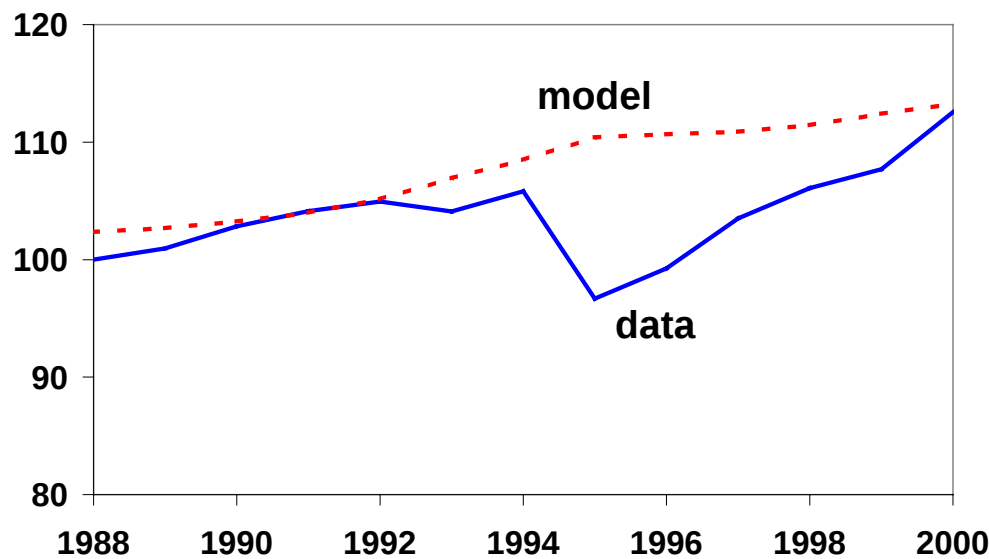
no tax reform



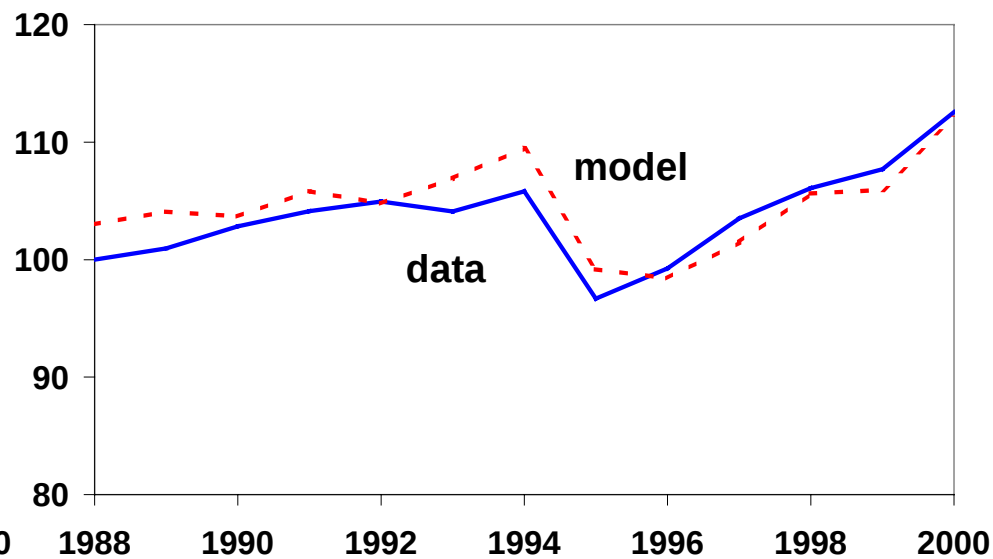
constant trade balance



trend TFP



taxes/trade balance/TFP



See

"Great Depressions of the Twentieth Century,"
special volume of ***Review of Economic
Dynamics***, 5 (2002), edited by Timothy J. Kehoe
and Edward C. Prescott.

Revised and expanded version reprinted as ***Great
Depressions of the Twentieth Century***, Federal
Reserve Bank of Minneapolis, forthcoming.