T. J. Kehoe, "An Evaluation of the Performance of Applied General Equilibrium Models of the Impact of NAFTA," in T. J. Kehoe, T. N. Srinivasan, and J. Whalley, editors, *Frontiers in Applied General Equilibrium Modeling: Essays in Honor of Herbert Scarf*, Cambridge University Press, 2005, 341-77.

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: Kehoe-Polo-Sancho (1992) evaluation of the performance of the 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) evaluation of the performance of the Brown-Stern (1989) model of the 1989 Canada-U.S. FTA.

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		0.30	0.77	0.85
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		-0.08	0.54	0.67

Measures of Accuracy of Model Results

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

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

3, 4. Estimated coefficients a and b from the (weighted) regression

$$x_i^{data} = a + bx_i^{model} + e_i.$$

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		0.16	0.80	0.77
variance decomposition of change		0.11	0.73	0.71
regression coefficient *a*		-0.52	-0.52	-0.52
regression coefficient *b*		0.44	0.75	0.67

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

direction of exports	data 1985-1986	model policy only	model shocks only	model 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	-17.7
weighted correlation with data		0.69	0.77	0.90
variance decomposition of change		0.02	0.17	0.24
regression coefficient *a*		-12.46	2.06	5.68
regression coefficient *b*		5.33	2.21	2.37

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
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		0.73	-3.45	0.85
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
regression coefficient *a*		0.00	0.00	0.00
regression coefficient *b*		0.87	1.49	1.24

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
correlation with data		0.99	-0.70	0.92
variance decomposition of change		0.93	0.08	0.86
regression coefficient *a*		-0.06	0.35	-0.17
regression coefficient *b*		0.74	-1.82	0.80

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.

For the past three decades, the tool of choice for analyzing the impact of trade policy has been the multisectoral applied GE model.

At a conference organized by the U.S. International Trade Commission, held in February 1992 at the request of the U.S. Congress, to which all economists studying the impact of NAFTA had been invited, 10 of the 12 studies presented used applied GE models.

This is still the sort of model used to analyze policies like the U.S.-Central America-Dominican Republic Free Trade Agreement and the U.S.-Korea Free Trade Agreement.

Typical sort of model: Static applied general equilibrium model with 20-40 industries, imperfect competition (Dixit-Stiglitz or Eastman-Stykolt) in some industries, perfect competition and Armington aggregators in others.

Comparison of predictions of model with changes that occurred over 1988–2006 (1988–2006 for Mexico-United States)

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

Cox-Harris model of Canada

Sobarzo model of Mexico

Changes in Canadian Exports relative to Canadian GDP (percent)

sector	1988–2006 data	BDS model	1988–2006 data	BDS model
agriculture	166.3	3.1	37.3	3.4
mining and quarrying	-17.9	-0.3	257.2	0.4
food	160.1	2.2	69.8	8.9
textiles	180.8	-0.9	131.5	15.3
clothing	1478.9	1.3	76.3	45.3
leather products	72367.2	1.4	-0.4	11.3
footwear	—	3.7	37.8	28.3
wood products	2128.6	4.7	33.9	0.1
furniture and fixtures	2009.4	2.7	125.8	12.5
paper products	56.6	-4.3	-48.8	-1.8
printing and publishing	1186.7	-2.0	43.1	-1.6
chemicals	371.5	-7.8	113.5	-3.1
petroleum and products	8453.5	-8.5	161.9	0.5
rubber products	14.8	-1.0	71.5	9.5
nonmetal mineral products	103.2	-1.8	28.9	1.2
glass products	-66.7	-2.2	32.8	30.4
iron and steel	210.1	-15.0	30.7	12.9
nonferrous metals	2019.0	-64.7	28.7	18.5
metal products	232.9	-10.0	74.8	15.2
nonelectrical machinery	218.8	-8.9	43.2	3.3
electrical machinery	707.2	-26.2	95.7	14.5
transportation equipment	624.8	-4.4	-0.7	10.7
misc. manufactures	674.1	-12.1	72.0	-2.1
weighted correlation with data		-0.32		-0.23
regression coefficient *a*		178.63		64.83
regression coefficient *b*		-16.75		-2.70

Multisectoral applied general equilibrium models constructed to analyze the impact of the U.S.-Canada Free Trade Agreement and the North American Free Trade Agreement did not perform well.

Fox (1999, 2003)

Kehoe (2004)

Much of the expansion of exports after trade liberalization is exports of products that were exported little or not at all before the policy change.

Kehoe and Ruhl (2003, 2009)

Recent research in international trade has devloped models in which there is an extensive margin of trade that responds to policy changes

Eaton and Kortum (2002)

Melitz (2003)

Goal:

Build models with

Industries (~20)

Products (~1,000)

Firms or Plants (~10,000)

Kehoe and Ruhl (2003, 2009)

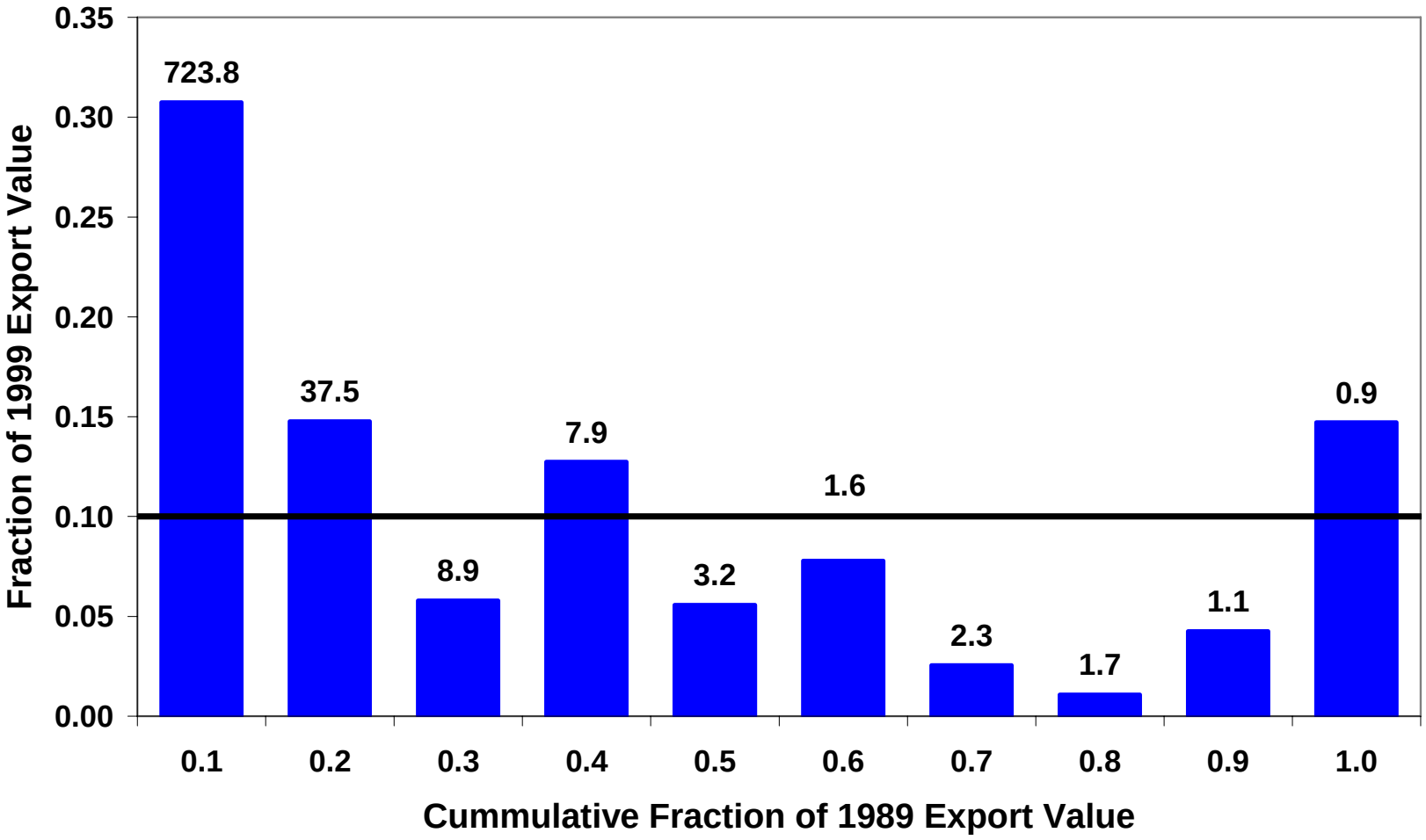
Data:
four-digit SITC bilateral trade data (789 categories — source: OECD).

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.

Let us pay particular attention to least traded products — the products with the least trade that cumulatively account for 10 percent of trade.

Composition of Exports: Canada to Mexico



Methodology for comparing results of models with data

Kehoe, Polo, and Sancho (1995), Kehoe (2005)

For exports by country i of industry j to country k, x_{ij}^k,

$$z_{ij}^k = 100\left(\frac{x_{ijT_1}^k / y_{iT_1}}{x_{ijT_0}^k / y_{iT_0}} - 1\right)$$

where y_{it} is the current price GDP in country i in year t

To compare the predictions of the model with the changes in data, we calculate the weighted correlation coefficient and the coefficients a and b from the weighted regression

$$\min_{a,b} \sum_{j=1}^{n} \alpha_j \left(a + b z_j^{model} - z_j^{data}\right)^2$$

How to turn least traded products data into predictions:

Predict that least traded products will have their exports grow $a+b$ percent faster than the exporting country's GDP and other products grow a percent faster.

For a particular industry, this prediction becomes

$$a(1-s_i)+(a+b)s_i = a+bs_i,$$

where s_i is the fraction of the industry's exports made up of least traded products in the base year.

Notice that this method does not make use of the products with 0 recorded trade.

Product-industry detail

Use concordance between the ISIC and the SITC based on those in the World Bank's Trade and Production Database (Nicita and Olarreaga, 2001, 2006)

Canadian exports of chemicals to the United States grew 113.5 percent while the BDS model predicted −3.1 percent.

88 complete 4-digit SITC categories — 80 least traded.

Parts of another 27 categories — 11 least traded.

Compared to Canadian GDP, the 22 percent of 1988 exports of chemicals that are least traded increase by 212 percent, while the other 78 percent increase by only 32 percent.

Compared to Canadian GDP

Exports of 5823 (Alkyds and Other Polyesters) increases by 1,285 percent

Exports of 5832 (Polypropylene) increases by 738 percent

Exports of 5121 (Acyclic Alcohols and their Halogenated and Derivatives) decreases by 37 percent.

Changes in Canadian Exports relative to Canadian GDP (percent)

sector	Canada to Mexico			Canada to United States		
	1988–2006 data	BDS model	1988 least traded	1988–2006 data	BDS model	1988 least traded
agriculture	166.3	3.1	0.05	37.3	3.4	0.34
mining and quarrying	-17.9	-0.3	0.00	257.2	0.4	0.03
food	160.1	2.2	0.07	69.8	8.9	0.26
textiles	180.8	-0.9	1.00	131.5	15.3	1.00
clothing	1478.9	1.3	1.00	76.3	45.3	0.53
leather products	72367.2	1.4	1.00	-0.4	11.3	1.00
footwear	—	3.7	—	37.8	28.3	1.00
wood products	2128.6	4.7	1.00	33.9	0.1	0.05
furniture and fixtures	2009.4	2.7	1.00	125.8	12.5	0.03
paper products	56.6	-4.3	0.05	-48.8	-1.8	0.04
printing and publishing	1186.7	-2.0	1.00	43.1	-1.6	0.07
chemicals	371.5	-7.8	0.15	113.5	-3.1	0.22
petroleum and products	8453.5	-8.5	0.99	161.9	0.5	0.72
rubber products	14.8	-1.0	0.57	71.5	9.5	0.11
nonmetal mineral products	103.2	-1.8	1.00	28.9	1.2	0.42
glass products	-66.7	-2.2	1.00	32.8	30.4	0.41
iron and steel	210.1	-15.0	0.03	30.7	12.9	0.31
nonferrous metals	2019.0	-64.7	1.00	28.7	18.5	0.03
metal products	232.9	-10.0	0.51	74.8	15.2	0.19
nonelectrical machinery	218.8	-8.9	0.18	43.2	3.3	0.24
electrical machinery	707.2	-26.2	0.28	95.7	14.5	0.27
transportation equipment	624.8	-4.4	0.02	-0.7	10.7	0.01
misc. manufactures	674.1	-12.1	1.00	72.0	-2.1	0.42
weighted correlation with data		-0.32	0.29		-0.23	0.29
regression coefficient *a*		178.63	192.29		64.83	29.74
regression coefficient *b*		-16.75	759.76		-2.70	144.11

Changes in Mexican Exports relative to Mexican GDP (percent)

	Mexico to Canada			Mexico to United States		
sector	**1988–2006 data**	**BDS model**	**1988 least traded**	**1989–2006 data**	**BDS model**	**1989 least traded**
agriculture	13.6	-4.1	0.06	34.7	2.5	0.09
mining and quarrying	102.9	27.3	0.07	-3.7	26.9	0.02
food	-5.6	10.8	0.52	196.3	7.5	0.35
textiles	92.9	21.6	0.26	43.6	11.8	0.63
clothing	1082.2	19.2	1.00	-70.2	18.6	0.28
leather products	789.1	36.2	1.00	-69.6	11.7	0.42
footwear	-52.5	38.6	1.00	-64.6	4.6	0.00
wood products	221.8	15.0	1.00	68.7	-2.7	0.26
furniture and fixtures	1852.0	36.2	0.09	-62.4	7.6	0.01
paper products	38.7	32.9	0.06	207.8	13.9	0.17
printing and publishing	1375.5	15.0	1.00	3.2	3.9	1.00
chemicals	209.6	36.0	0.68	98.7	17.0	0.52
petroleum and products	116.2	32.9	0.01	46.7	34.1	0.07
rubber products	2437.9	-6.7	1.00	-5.3	-5.3	1.00
nonmetal mineral products	40.4	5.7	0.42	1.6	3.7	0.34
glass products	12.2	13.3	0.16	64.3	32.3	0.29
iron and steel	-51.4	19.4	0.40	-34.1	30.8	0.43
nonferrous metals	24.8	138.1	0.24	113.3	156.5	0.10
metal products	487.8	41.9	0.51	103.3	26.8	0.29
nonelectrical machinery	120.7	17.3	0.09	34.2	18.5	0.18
electrical machinery	326.1	137.3	0.06	120.0	178.0	0.01
transportation equipment	103.5	3.3	0.01	128.5	6.2	0.02
misc. manufactures	1265.1	61.1	0.62	34.7	43.2	0.19
weighted correlation with data		0.45	0.24		-0.14	0.003
regression coefficient *a*		100.02	136.33		49.49	73.29
regression coefficient *b*		1.80	313.80		-0.10	1.56

Changes in U.S. Exports relative to U.S. GDP (percent)

	United States to Canada			United States to Mexico		
sector	**1988–2006 data**	**BDS model**	**1988 least traded**	**1989–2006 data**	**BDS model**	**1989 least traded**
agriculture	-8.6	5.1	0.29	11.3	7.9	0.10
mining and quarrying	83.7	1.0	0.19	60.9	0.5	0.21
food	68.8	12.7	0.37	108.9	13	0.19
textiles	-4.2	44.0	0.43	265.9	18.6	0.49
clothing	55.7	56.7	1.00	-14.9	50.3	0.27
leather products	-59.3	7.9	1.00	342.8	15.5	0.60
footwear	-56.1	45.7	1.00	-72.3	35.4	0.00
wood products	1.7	6.7	0.37	10.3	7.0	0.19
furniture and fixtures	114.7	35.6	0.01	29.5	18.6	0.02
paper products	41.9	18.9	0.13	32.8	-3.9	0.03
printing and publishing	-0.1	3.9	0.04	77.6	-1.1	0.17
chemicals	69.2	21.8	0.23	167.3	-8.4	0.15
petroleum and products	133.4	0.8	0.73	242.7	-7.4	0.01
rubber products	26.8	19.1	0.05	176.0	12.8	0.11
nonmetal mineral products	-15.3	11.9	0.63	94.1	0.8	0.75
glass products	-9.7	4.4	0.25	104.6	42.3	0.72
iron and steel	139.0	11.6	0.27	96.9	-2.8	0.25
nonferrous metals	16.1	-6.7	0.15	220.0	-55.1	0.09
metal products	25.6	18.2	0.17	159.1	5.4	0.12
nonelectrical machinery	-23.0	9.9	0.07	135.4	-2.9	0.11
electrical machinery	-14.9	14.9	0.04	109.9	-10.9	0.01
transportation equipment	-11.7	-4.6	0.01	137.0	9.9	0.05
misc. manufactures	8.6	11.5	0.18	77.0	-9.4	0.17
weighted correlation with data		0.37	0.57		-0.29	0.16
regression coefficient *a*		-3.35	-11.44		117.50	125.30
regression coefficient *b*		1.28	153.31		-1.26	95.50

Changes in North American trade relative to exporter's GDP

trade flow	period	BDS model			fraction least traded		
		correlation	***a***	***b***	**correlation**	***a***	***b***
Canada to Mexico	88–06	-0.32	178.63	-16.75	0.29	192.29	759.76
Canada to U.S.	88–06	-0.23	64.83	-2.70	0.29	29.74	144.11
Mexico to Canada	88–06	0.45	100.02	1.80	0.24	136.33	313.80
Mexico to U.S.	89–06	-0.14	49.49	-0.10	0.003	73.29	1.56
U.S. to Canada	88–06	0.37	-3.35	1.28	0.57	-11.44	153.31
U.S. to Mexico	89–06	-0.29	117.50	-1.26	0.16	125.30	95.50
weighted average		-0.01	45.73	-0.83	0.33	33.03	125.09
pooled regression		0.02	46.19	0.04	0.23	33.27	123.87

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.