Predicting the effects of NAFTA: Now we can do it better!

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Introduction

- NAFTA's merits were hotly debated before its signing
- Quantitative economic analysis was extensively used using computable general equilibrium (CGE) models
  - The models were generally similar, with the type of competition in the goods market being the biggest difference
  - Models relied on the Armington (1969) assumption to explain two-way trade between countries and home bias in consumption
- Their predictions pointed to little effect on trade, output, and employment in the U.S., and moderate effects on Mexico

- In actuality, NAFTA had a significant effect on trade between its members and a small-to-moderate effect on their incomes and employment (Burfisher, Robinson, and Thierfelder, 2001; Anderson and van Wincoop, 2002; Romalis, 2007, papers presented at this conference)
- Between 1993 and 2000:
  - Total NAFTA trade relative to the total NAFTA GDP grew 57%
  - Fraction of U.S. income that was spent on Mexican goods grew 128%
  - Fraction of Mexican goods in total Canadian imports went up 61%
- There were two problems with economic predictions (Kehoe, 2005):
  - CGE models significantly underpredicted the effect of NAFTA on trade, across all industries
  - Forecasted industry-level changes in bilateral trade have little correlation with the actual post-NAFTA industry-level changes

This paper:

- Proposes an alternative model for predicting the effects of trade liberalizations
- Instead of using the Armington assumption, this model employs the methodology of Eaton and Kortum to explain intra-industry trade.
- The model is used to predict the effects of NAFTA from the point of view of 1989
- The predictions are compared with the post-NAFTA data and pre-NAFTA predictions of other CGE models, recognizing that events other than NAFTA affected post-NAFTA trade

Explaining two-way trade without the Armington assumption

- The Armington assumption:
  - Production in an industry is done by a representative producer
  - Each country produces its own unique variety of each good
  - Consumers have CES preferences for these varieties
  - Home bias is explained by preferences (nested CES forms)
- An alternative to the Armington assumption: a model with heterogeneous producers (Eaton and Kortum)
  - Production is done by a multitude of producers
  - Each country can produce all varieties
  - Source of producer heterogeneity is productivity
    - This methodology is backed up by producer-level studies (Bernard and Jensen (1995, 1999), Aw et al. (1998), Clerides et al. (1998), Bernard et al. (2003), Eaton et al. (2004))
  - Home bias is explained by trade costs
  - Heterogeneous-producer models can be incorporated into traditional neoclassical model of trade that have many industries and several factors of production so that inferences can be made about
    - the pattern of trade
    - the role for factor endowments

- However, before we can believe the predictions of the new models, they need to be evaluated
- A general equilibrium model with heterogeneous producers is evaluated in
  - Shikher (2007): evaluating predictions regarding specialization
  - This paper: evaluating predictions regarding trade liberalization

Evaluating a model by simulation:

- Not a common approach in international trade, but common in other fields of economics, such as real business cycle literature
- Computable models of trade are often used for forecasting, so a small forecasting error is an important characteristic
- Fitting the model to data and evaluating the fit is not a good approach with large complicated models: individual equations may have a good statistical fit, but the model as a whole performs poorly

Model of trade with heterogeneous producers

Overview:

- General equilibrium model of trade with multiple industries and factors of production
- There are N countries (indexed by n or i).
- There are J industries in each country (indexed by j or m).
- Two factors of production: capital and labor, mobile across industries. Endowments are fixed.
- Production has constant returns to scale.
- Market structure is perfect competition.
- Goods can have final or intermediate uses.
- At the industry level, the framework of Eaton and Kortum (2002) with heterogenous producers explains intra-industry trade
- Trade is affected by
  - Technological differences (Ricardian comparative advantage)
  - Factor endowment and factor intensity differences (Heckscher-Ohlin motive)
  - Taste differences
  - Bilateral asymmetric trade costs

Preferences:

- Consumers have Cobb-Douglas preferences across industries, each industry having share ψ_{nj}.
- The consumer utility in country n is then $U_n = \prod_{j=1}^{J} C_{nj}{}^{\psi_{nj}}$, where C_{nj} is total consumption of industry j goods in country n.

Production:

- In each industry j, there are many products. Each product is indexed by $u \in [0, 1]$.
- For each product u, there are many potential producers engaged in perfect competition, so price of u is equal to it marginal cost.
- Each product u is made with total factor productivity $z_{nj}(u)$.
- Production inputs are capital, labor, and a bundle of intermediate goods.
- All producers within an industry use the same constant-returns-to-scale Cobb-Douglas production function (but different total factor productivity).
- Capital share is α_j. Labor share is β_j.

- The cost of the intermediate goods bundle is ρ_{nj}.
- The bundle is a Cobb-Douglas aggregation of goods of all industries, so $\rho_{nj} = \prod_{m=1}^{J} p_{nm}^{\eta_{jm}}$, where p_{nm} is the price index in industry m of country n and η_{jm} is the share of industry m goods in the intermediate input bundle of industry j.
- Producers charge a price that is equal to cost.
- The total cost of producing one unit of good u by a producer in industry j of country n is $\frac{c_{nj}}{z_{nj}(u)}$, where $c_{nj} = r_n^{\alpha_j} w_n^{\beta_j} \rho_{nj}^{1-\alpha_j-\beta_j}$ is the cost of all inputs in industry j of country n.

Productivity:

- $z_{nj}(u)$, production productivity of good u, is random.
- Motivation: productivity is derived from R&D, which is an uncertain process.
- In this model, productivity is a random variable drawn from a distribution called Fréchet.
- This distribution has two parameters: $T_{nj} > 0$ and $\theta > 1$.
- Parameters T_{nj} governs the mean of the distribution, while parameter θ governs the variance (bigger θ means less variance).

Technological comparative advantage:

- Parameters T_{nj} determine the comparative advantage of countries across sectors. For example, the country with the higher T_{n1} / T_{n2} than country n has a comparative advantage in sector 1.

Trade costs:

- The cost of trading any good u in sector j has an "iceberg" form: to receive \$1 of product in country n requires sending $d_{nij} \geqslant 1$ dollars of product from country i.
- By definition, domestic transport costs are set to one: $d_{nnj} \equiv 1$.
- The cost of good l made by a producer in country i and delivered to n is then $\frac{c_{ij} d_{nij}}{z_{nj}(u)}$.

Solving the model:

- The price index for industry j in country n is $p_{nj} = \gamma \Phi_{nj}^{-1/\theta}$ (derivation is not shown), where γ is a constant and $\Phi_{nj} = \sum_{i=1}^{N} T_{ij} \left(c_{ij} d_{nij}\right)^{-\theta}$.
- Note that Φ_{nj} summarizes technology, input costs, and transport costs around the world.
- Let π_{nij} be the fraction of n's expenditure spent on i's goods in industry j (this is called import share of i in n; it is a measure of trade): $\pi_{nij} = \frac{X_{nij}}{X_{nj}}$, where X is spending.

$$\pi_{nij} = \frac{T_{ij} \left(c_{ij} d_{nij}\right)^{-\theta}}{\sum_{i=1}^{N} T_{ij} \left(c_{ij} d_{nij}\right)^{-\theta}}.$$

(derivation is not shown).

Equilibrium conditions:

For equilibrium in the goods market, output must equal spending:

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} X_{nj} = \sum_{n=1}^{N} \pi_{nij} \left(Z_{nj} + C_{nj} \right),$$

where Z_{nj} and C_{nj} are the amounts spent by country n on industry j's intermediate and consumption goods.

$$Z_{nj} = \sum_{m} p_{nj} M_{nmj} = \sum_{m} \eta_{mj} \rho_{nm} M_{nm} = \sum_{m} \eta_{mj} w_n L_{nm} \left(1 - \alpha_m - \beta_m\right) / \beta_m,$$

where M is the quantity of intermediate goods, and L_{nm} is the stock of labor employed in industry m of country n.

The second-to-last equality follows from the Cobb-Douglas aggregation of the intermediate input bundle while the last equality follows from the Cobb-Douglas functional form of the cost function.

Consumption: $C_{nj} = \psi_{nj} Y_n$, where Y_n is the total income (GDP) in country n and ψ_{nj} is the share of industry j in country n, as previously defined. Parameters ψ_{nj} determine tastes

Country income: $Y_i = w_i L_i + r_i K_i$

Total factor stocks constraints: $\sum_{j=1}^{J} K_{ij} = K_i$ and $\sum_{j=1}^{J} L_{ij} = L_i$, where K_i and L_i are country i's factor stocks, which are fixed.

- Due to data limitations, only the manufacturing industries are modeled.
- The nonmanufacturing sector's price index is normalized to 1 and its purchases of the manufacturing intermediates are treated as final consumption.
- Country income Y_i is the sum of the manufacturing income Y_i^M and nonmanufacturing income Y_i^O:

$$Y_i = Y_i^M + Y_i^O = w_i L_i + r_i K_i + Y_i^O.$$

- Nonmanufacturing income is $Y_i^O = \xi_i Y_i$, where $\xi_i \geqslant 0$ is a parameter.
- Factor stocks K_i and L_i are specific to manufacturing.
- Capital and labor are not mobile between the manufacturing and nonmanufacturing sectors.
- Model parameters are α_j, β_j, η_{jm}, θ, ψ_{nj}, T_{nj}, K_i, L_i, and ξ_i.
- The model has $N^2 J + 5NJ + 3N$ unknowns: X_{nij}, c_{nj}, p_{nj}, K_{nj}, L_{nj}, Q_{nj}, Y_n, w_n, and r_n.

Parametrizing the model:

- Data: 8 two-digit industries in 19 OECD countries, 1989
- Labor shares, output, wages, UNIDO; capital shares, authors's own study; intermediate input shares, OECD; technology parameter θ from literature
- Bilateral trade in 1989, Feenstra; bilateral trade post-NAFTA, OECD; GDP, UN

Estimated mean productivity draws in each country and industry, $T^{1/\theta}$

	Food	Textile	Wood	Paper	Chemicals	Nonmet.	Metals	Machinery
Canada	0.852	0.862	0.920	0.966	0.797	0.788	0.989	0.795
Mexico	0.571	0.564	0.422	0.447	0.609	0.570	0.629	0.500
U.S.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Australia	0.847	0.755	0.614	0.677	0.693	0.688	0.897	0.702
Austria	0.646	0.798	0.651	0.745	0.717	0.824	0.786	0.728
Finland	0.590	0.737	0.746	0.904	0.706	0.693	0.841	0.728
France	0.886	0.958	0.787	0.850	0.887	0.972	0.938	0.871
Germany	0.831	0.954	0.833	0.875	0.925	0.989	0.955	0.924
Greece	0.684	0.687	0.449	0.494	0.560	0.663	0.679	0.477
Italy	0.812	1.045	0.878	0.826	0.846	1.040	0.887	0.883
Japan	0.738	0.970	0.773	0.868	0.935	1.049	1.001	1.025
Korea	0.660	0.871	0.559	0.612	0.724	0.683	0.794	0.713
New Zeal.	0.883	0.709	0.625	0.682	0.658	0.567	0.706	0.603
Norway	0.758	0.660	0.656	0.776	0.741	0.670	0.869	0.701
Portugal	0.616	0.648	0.507	0.580	0.538	0.636	0.580	0.509
Spain	0.771	0.788	0.645	0.709	0.737	0.829	0.820	0.693
Sweden	0.662	0.721	0.733	0.848	0.746	0.750	0.845	0.785
Turkey	0.595	0.621	0.392	0.374	0.548	0.604	0.648	0.429
U.K.	0.838	0.871	0.704	0.805	0.848	0.878	0.881	0.822

Factor intensities:

Industry	Capital (α_j)	Labor (β_j)	Inputs*	Cap. in VA**
Food	0.062	0.103	0.835	0.37
Textile	0.058	0.201	0.741	0.22
Wood	0.064	0.182	0.755	0.26
Paper	0.081	0.185	0.733	0.31
Chemicals	0.082	0.115	0.803	0.42
Nonmet.	0.106	0.185	0.709	0.36
Metals	0.086	0.133	0.781	0.39
Machinery	0.071	0.186	0.743	0.28

*The share of intermediate inputs is $(1-\alpha_i-\beta_i)$.

**The share of capital in value added is $\alpha_i/(\alpha_i+\beta_i)$.

Labor costs (manuf.):

Country	Compensation
Australia	$19,115
Austria	$20,767
Canada	$25,991
Finland	$23,561
France	$28,312
Germany	$25,651
Greece	$9,369
Italy	$28,251
Japan	$26,902
Korea	$8,346
Mexico	$4,337
New Zeal.	$15,894
Norway	$25,180
Portugal	$6,780
Spain	$14,819
Sweden	$20,918
Turkey	$4,120
U.K.	$18,745
U.S.	$26,203

Capital endowments:

Country	
Australia	$32,744
Austria	$49,102
Canada	$49,643
Finland	$64,949
France	$58,116
Germany	$39,144
Greece	$35,027
Italy	$51,878
Japan	$51,527
Korea	$31,624
Mexico	$13,641
New Zealand	$44,651
Norway	$66,475
Portugal	$19,844
Spain	$24,751
Sweden	$54,628
Turkey	$20,116
United Kingdom	$33,572
United States	$44,973

Description of experiments

- Pre-NAFTA studies:
  - Models were parametrized with data from late 1980s
  - They simulated both U.S.-Canada FTA and NAFTA
  - Simulations entailed removal of policy-related trade barriers between U.S., Canada, and Mexico
  - Average tariffs were 5% in U.S., 12% in Mexico, and 8% in Canada
  - Some studies also simulated the removal of non-tariff barriers (NTBs)
  - Inclusion of NTBs approximately doubled the protection levels removed
- FTA and NAFTA:
  - FTA goes into effect in 1989, NAFTA in 1994
  - Gradual removal of policy-related trade barriers
  - Average phase-out periods in NAFTA: 1.4 years for U.S., 5.6 years for Mexico (Kowalczyk and Davis, 1996)
  - Maximum phase-out period was 10 years

Policy-related trade barriers

(from Nicita, A. and Olarreaga, M. 2007. Trade, production and protection database 1976-2004, World Bank Economic Review)

Table 2(a) Tariffs

Country	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery	Manuf.
Canada	8.83	17.65	8.48	3.46	8.26	7.78	4.83	5.63	8.51
Mexico	15.93	17.48	15.02	5.84	12.35	15.26	9.86	13.74	13.71
United States	2.14	10.64	2.47	0.62	4.48	7.43	3.04	3.37	4.68

Table 2(b) Tariff equivalents of non-tariff barriers

Canada	3.23	7.95	12.96	0.00	1.23	0.00	11.82	0.87	3.33
Mexico	26.68	22.89	8.39	11.12	17.09	18.11	4.03	19.21	17.70
United States	11.07	5.81	2.63	0.67	3.28	0.51	0.00	4.05	4.10

Table 2(c) Total policy-related trade protection

Canada	12.06	25.60	21.44	3.46	9.49	7.78	16.65	6.50	11.84
Mexico	42.61	40.37	23.41	16.96	29.44	33.37	13.89	32.95	31.42
United States	13.21	16.45	5.10	1.29	7.76	7.94	3.04	7.42	8.78

Post-NAFTA evaluation of forecasts

- Kehoe (2005) systematically evaluates pre-NAFTA forecasts regarding trade and finds little or negative correlation between predicted and actual changes
- This study will compare forecasts to the actual changes during 1989-2008
- Look at:
  - NAFTA trade (relative to total trade or GDP)
  - Import shares (shares of country i in country n's imports of industry j)
- Comparison measures:
  - Correlation between predicted and actual data
  - Intercept and slope from the regression of actual on predicted
  - Note: R^2 for this regression is correlation squared

Events other than NAFTA have affected the data:

1. Technological growth
   - Affects both trade and GDP
   - By most estimates, technological change in Mexico was not much greater than in the U.S.
   - Differential (across industries) technological growth is possible
2. Peso devaluation
   - Affects all industries
   - The effect most likely dissipated by 2008
3. Segmentation of production
   - Affected all countries, not just NAFTA countries
4. Rise of China
   - Chinese import share in the U.S. increased mostly at the expense of Japanese and other Asian countries' import shares
   - We observe an increase in the share of Mexican imports in the U.S.

- Pre-NAFTA studies reviewed (originally published in 1992, then republished in 1994, 1995):
  - Brown, Deardorff, and Stern (BDS): IRS, removes tariffs and NTBs, allows FDI into Mexico
  - Cox and Harris: IRS, removes tariffs and NTBs
  - Sobarzo: IRS, removes tariffs, allows FDI into Mexico
  - Roland-Holst-Reinert-Shiells (RRS): CRS and IRS, tariffs only and tariffs+NTBs
- Model of this paper: HPPC (heterogeneous producers, perfect competition)

Results

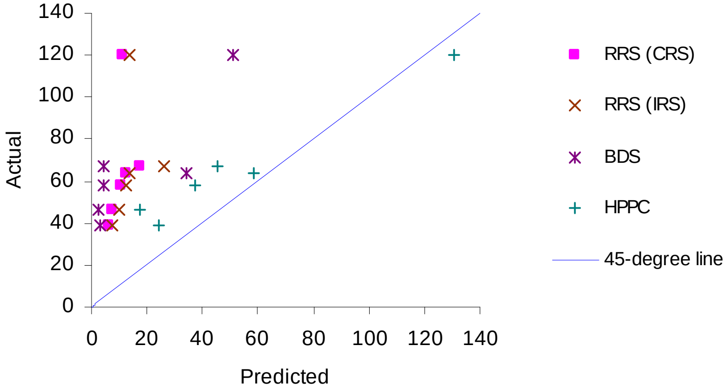
Actual vs. predicted percent changes in NAFTA trade

Measure	Predicted HPPC	Actual 1989-2008
NAFTA trade relative to the total trade of the NAFTA countries	25.9	24.8
NAFTA trade relative to the total income of the NAFTA countrie	62.2	66.5

Actual vs. predicted percent changes in total exports and imports

	Actual	Predicted			
Variable	1989–2008	RRS (CRS)	RRS (IRS)	BDS	HPPC
Canadian exports	66.7	17.1	26.0	4.3	45.4
Canadian imports	58.2	10.5	12.3	4.2	37.1
Mexican exports	120.3	11.1	14.0	50.8	130.4
Mexican imports	64.2	12.4	13.9	34.0	58.3
U.S. exports	39.2	6.0	7.8	2.9	24.0
U.S. imports	46.2	7.7	10.1	2.3	17.5
Correlation with data		0.38	0.29	0.86	0.98

Actual vs. predicted percent changes in total exports and imports



Percent changes in import shares predicted by the HPPC model

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	36.3	188.2	21.0	14.9	23.7	21.1	16.0	65.6
Canada	U.S.	16.0	64.5	9.9	2.4	6.9	10.2	17.1	6.5
Mexico	Canada	-9.6	-36.3	-41.8	-24.9	-23.6	-22.9	-3.9	-2.8
Mexico	U.S.	19.6	21.1	2.1	4.0	13.7	25.5	9.0	18.7
U.S.	Canada	32.6	121.0	5.5	-2.8	30.5	26.5	11.3	49.0
U.S.	Mexico	107.1	337.9	60.1	37.2	73.8	69.0	28.9	129.1

Note: Each observation is a share of country *i* in country *n*'s imports of industry *j*.

Percent changes in import shares found in data (1989-2008)

Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	92.71	202.83	1580.50	185.78	413.43	208.89	-59.72	254.06
Canada	U.S.	36.15	72.85	16.11	8.95	14.56	25.98	6.83	2.82
Mexico	Canada	20.83	-65.01	846.37	-40.81	5.36	-68.86	-70.19	-35.60
Mexico	U.S.	18.29	22.85	-10.96	-1.35	8.55	3.86	-7.76	4.73
U.S.	Canada	73.45	93.67	-4.37	-11.19	5.78	17.65	-9.06	-5.69
U.S.	Mexico	81.93	291.84	52.06	-1.31	45.92	31.01	19.95	141.12

Percent changes in import shares predicted by the BDS model									
Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	10.0	11.0	22.7	15.0	-7.5	5.1	11.2	15.7
Canada	U.S.	7.4	24.3	3.4	3.0	2.2	3.8	2.9	1.6
Mexico	Canada	-7.0	5.6	12.1	0.8	7.0	156.0	6.2	14.4
Mexico	U.S.	7.4	10.5	11.3	2.0	2.2	7.1	5.7	10.8
U.S.	Canada	8.1	23.3	1.4	-0.1	2.8	58.9	8.0	4.2
U.S.	Mexico	10.3	14.7	4.4	4.4	-6.1	-23.6	14.8	41.9

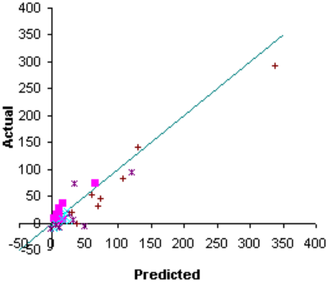
Percent changes in import shares found in data (1989-2008)									
Importer	Exporter	Food	Textile	Wood	Paper	Chemicals	Nonmetals	Metals	Machinery
Canada	Mexico	92.71	202.83	1580.50	185.78	413.43	208.89	-59.72	254.06
Canada	U.S.	36.15	72.85	16.11	8.95	14.56	25.98	6.83	2.82
Mexico	Canada	20.83	-65.01	846.37	-40.81	5.36	-68.86	-70.19	-35.60
Mexico	U.S.	18.29	22.85	-10.96	-1.35	8.55	3.86	-7.76	4.73
U.S.	Canada	73.45	93.67	-4.37	-11.19	5.78	17.65	-9.06	-5.69
U.S.	Mexico	81.93	291.84	52.06	-1.31	45.92	31.01	19.95	141.12

Relationships between actual and predicted changes

		HPPC model			BDS model		
Importer	Exporter	Correlation	Intercept*	Slope	Correlation	Intercept*	Slope
Canada	Mexico	-0.15	423.10	-1.31	0.41	111.09	23.89
Canada	U.S.	0.91	5.71	1.04	0.95	5.54	2.88
Mexico	Canada	-0.57	-185.64	-12.53	-0.14	93.82	-0.81
Mexico	U.S.	0.72	-9.46	1.00	0.10	2.54	0.31
U.S.	Canada	0.77	-7.59	0.81	0.28	12.26	0.58
U.S.	Mexico	0.98	-15.70	0.93	0.44	65.84	2.23
*Note: R^2 for these regressions is correlation^2							

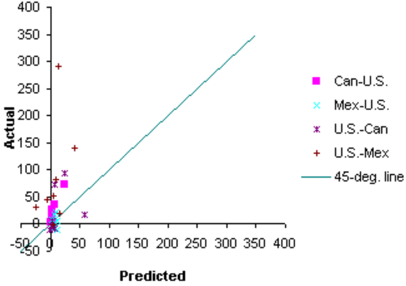
Actual vs. predicted percent changes in import shares by industry

Model of this paper



correlation=0.95

BDS model



correlation=0.31

This represents 99% of NAFTA trade

Reconciling the model of this paper and BDS

(looking at the relationships between predicted and actual changes in industry-level import shares)

	HPPC				BDS			
	Correl.	Intercept	Slope	Av(abs)*	Correl.	Intercept	Slope	Av(abs)*
Original	0.95	-4.6	0.87	42.8	0.31	21.23	1.33	10.4
$\theta=\sigma=3$	0.87	-13.6	4.75	9.9				
$\theta=\sigma=3$ and c.i.f. barriers	0.93	-16.5	2.2	22.8				
All of the above and BDS tariffs	0.88	-17.1	2.61	19.2				
All of the above and NTBs	0.74	-0.52	2.82	7.8	0.44	13.8	1.1	9.6

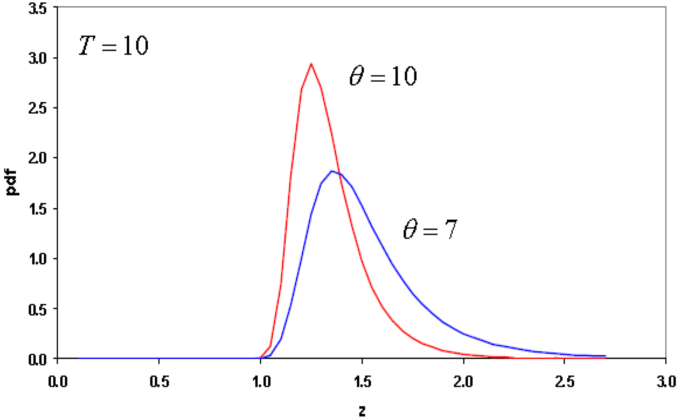
Note: Av(abs) is the average absolute percent change in import shares. Its value in the data is 35.9%.

Conclusion

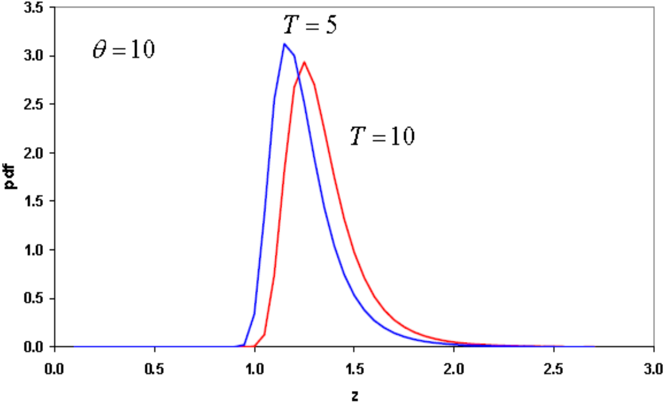
- NAFTA is a major natural experiment that is useful for evaluating models of trade
- The pre-NAFTA predictions regarding trade turned out to be off:
  - The changes in trade flows predicted by the pre-NAFTA models are much smaller than the actual changes that occurred after NAFTA
  - Models have done a poor job explaining the variation in trade changes across countries and industries.
- Pre-NAFTA models were often poorly documented, which made their evaluation difficult. This has been generally remedied.
- Pre-NAFTA studies used estimates of NTMs which were generally of poor quality. There has been much progress in this area.

- While the pre-NAFTA computable models of trade used the Armington (1969) methodology to explain intra-industry trade, this paper presents a model that uses the Eaton-Kortum (2002) methodology
- Using this framework on the industry level results in a highly tractable model that has all the usual neoclassical features with room for both Ricardian and Heckscher-Ohlin reasons for trade and asymmetrical industry-level trade costs.
- This paper evaluates the new model by using it to forecast the effects of NAFTA from the point of view of 1989
- The results are then compared with the post-NAFTA data and forecasts of other models of trade. The results show that the HPPC model makes fairly accurate predictions regarding NAFTA trade.
- We should consider moving away from the Armington-based models to simpler, more transparent heterogeneous producer models.

pdf of the Fréchet distribution



pdf of the Fréchet distribution



- Total trade costs d_{nij} are estimated by a gravity-like regression (as in Eaton and Kortum):

Starting from

$$\frac{\pi_{nij}}{\pi_{nnj}} = \frac{X_{nij}}{X_{nnj}} = \frac{T_{ij}}{T_{nj}} d_{nij}^{-\theta} \left(\frac{c_{ij}}{c_{nj}} \right)^{-\theta},$$

Define $S_{ij} \equiv T_{ij} c_{ij}^{-\theta}$ as a measure of international competitiveness of industry j in country i.
A gravity-like equation is obtained by taking logs of both sides of the previous equation and using the definition of S_{ij}:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta \log d_{nij} + \log S_{ij} - \log S_{nj}.$$

The trade barriers are proxied by the following trade cost function:

$$\log d_{nij} = d_{kj}^{phys} + b_j + l_j + f_j + m_{nj} + \delta_{nij}, \text{ where}$$

d_{kj}^{phys} $(k = 1, ..., 6)$ is the effect of physical distance lying in the kth interval
b is the effect of common border,
l is the effect of common language,
f is the effect of belonging to the same free trade area,
m_n is the overall destination effect,
δ_{ni} is the sum of transport costs that are due to all other factors.
The estimating equation is:

$$\log \frac{X_{nij}}{X_{nnj}} = -\theta d_{kj}^{phys} - \theta b_j - \theta l_j - \theta f_j + D_{ij}^{exp} + D_{nj}^{imp} - \theta \delta_{nij},$$

where $D_{ij}^{exp} = \log S_{ij}$ and $D_{nj}^{imp} = -\theta m_{nj} - \log S_{nj}$ are the exporter and importer dummy variables.

- The technology parameters T_{ij}, rates of return r_i, and costs c_{ij} are obtained by fitting a subset of the model to data:

The subset of the model is given by

$$c_{ij} = r_i^{\alpha_{kj}} w_i^{\alpha_{lj}} \prod_{m=1}^{J} \left[\gamma^{-\theta} \sum_{n=1}^{N} T_{nm} \left(d_{inm} c_{nm} \right)^{-\theta} \right]^{-\frac{\eta_{jm}\left(1-\alpha_{kj}-\alpha_{lj}\right)}{\theta}}$$

$$Q_{ij} = \sum_{n=1}^{N} \pi_{nij} X_{nj}$$

$$\pi_{nij} = \frac{T_{ij}\left(c_{ij} d_{nij}\right)^{-\theta}}{\sum_{i=1}^{N} T_{ij}\left(c_{ij} d_{nij}\right)^{-\theta}}$$

plus a long-run equilibrium condition $r_i = r^w$, where $r^w = 0.2$ is the world (gross) interest rate (only assumed in parametrization)

Values of Q_{ij}, X_{nj}, and w_i are taken from data.
The values of trade costs d_{nij} were estimated in the previous section.
The system has $2NJ$ equations and unknowns.

Then, the remaining parameters are calculated:
$K_{ij} = \alpha_j Q_{ij} / r_i$ and $L_{ij} = \beta_j Q_{ij} / w_i$.
$K_i = \sum_{j=1}^{J} K_{ij}$ and $L_i = \sum_{j=1}^{J} L_{ij}$
$\xi_i = 1 - (r_i K_i + w_i L_i) / Y_i$, where the total income Y_i is taken from data
$\psi_{ij} = C_{ij} / Y_i$, $C_{ij} = X_{ij} - Z_{ij} = X_{ij} - \sum_{m=1}^{J} \eta_{mj} (1 - \alpha_{km} - \alpha_{lm}) Q_{im}$.

Reasons for different forecasts of the new model and BDS model
Determination of trade in the Armington model:

$$\pi_{nij} = \frac{\lambda_{nij}^{\sigma-1} p_{nij}^{-(\sigma-1)}}{\sum_{s=1}^{N} \left(\lambda_{nsj}^{\sigma-1} p_{nsj}^{-(\sigma-1)} \right)}$$

In the model of this paper:

$$\pi_{nij} = \frac{T_{ij} \left(c_{ij} d_{nij} \right)^{-\theta}}{\sum_{i=1}^{N} T_{ij} \left(c_{ij} d_{nij} \right)^{-\theta}}$$

- Different elasticities
- Assuming c.i.f. vs. f.o.b. barriers
- Different barrier reductions
- Different treatments of NTBs
- Differences in other parameters