Nonlinear Dynamic Gravity Model of Bilateral Trade with Flexible Adjustment Speed

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Overview

1. Introduction and Backgrounds
2. Dynamic Adjustment Framework
3. Econometric Approach
4. Data
5. Estimation Results
6. Summary and Conclusion

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Main Findings

- This paper suggests dynamic framework of gravity estimation by implementing flexible adjustment speed.
- Introducing adjustment speed as function of trade policy allows us to quantify the role of trade policy in understanding the dynamics of bilateral trade flows.
- Increasing values of adjustment speed is consistent with the increased trade liberalizaton of developing nations.

Motivation and Related Literature

- Implementing dynamic panel data framework to the gravity equation has been introduced in international economics. (International migration : Mayda (2009), International trade : Olivero and Yotov (2012))

- Recent developments in dynamic panel data estimation of gravity were not enough to discuss the determinants of the dynamic nature of trade flows

- Our framework quantifies the trade adjustment for each country-pair using bilateral trade barriers so that we can understand the path dependence deeper.

Motivation and Related Literature

- Research on the dynamics of firm-level capital structure have implemented flexible (heterogeneous) adjustment.

- Modigliani and Miller (1958), Marsh (1982)

- Banerjee, Heshmati, and Wihlborg (1999), Heshmati (2001), Lööf (2004), Kim and Heshmati (2019) : Implemented flexible adjustment speed term while the endogeneity of lagged dependent variable is not covered.

- Öztekin and Flannery (2012) : Linear specification with inflexible adjustment speed. Blundell-Bond dynamic panel estimator.

- Jin, Zhao, and Kumbhakar (2020) : Nonlinear specification with flexible adjustment speed. GMM estimator which covers endegeneity of lagged dependent variable.

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Dynamic Adjustment Framework

$$X_{ij,t} - X_{ij,t-1} = \delta_{ij,t}(X^*_{ij,t} - X_{ij,t-1})$$

- $X_{ij,t}$: Log of bilateral trade flow from country i to country j in year t.
- $X^*_{ij,t}$: Log of predicted (expected) bilateral trade flow from country i to country j in year t
- $\delta_{ij,t}$: Adjustment parameter $\delta_{ij,t}$ explains the differences between the left hand side and the right hand side.

$$X^*_{ij,t} = F(A) = b_0 + b_1 A_{i,t} + b_2 A_{j,t} + b_3 A_{ij} + \epsilon^g$$

$$\delta_{ij,t} = G(Z) = d_0 + d_1 Z_{i,t} + d_2 Z_{j,t} + d_3 Z_{ij,t} + \epsilon^\delta$$

Dynamic Adjustment Framework

$$X_{ij,t} - X_{ij,t-1} = \delta_{ij,t}(X^*_{ij,t} - X_{ij,t-1})$$

- The main idea for this dynamic model is that the realized level of bilateral trade flow always tends to be different from the predicted level.
- The difference between realized level and predicted level is explained by adjustment speed term $\delta_{ij,t}$.
- $\delta_{ij,t}$ quantifies the difference between $X_{ij,t} - X_{ij,t-1}$ (realized difference) and $X^*_{ij,t} - X_{ij,t-1}$ (predicted difference).

Dynamic Adjustment Framework

$$X^*_{ij,t} = F(A) = b_0 + b_1 A_{i,t} + b_2 A_{j,t} + b_3 A_{ij} + \epsilon^g$$

$$\delta_{ij,t} = G(Z) = d_0 + d_1 Z_{i,t} + d_2 Z_{j,t} + d_3 Z_{ij,t} + \epsilon^\delta$$

- $X^*_{ij,t}$ is function of some variables A where $F(\cdot)$ is linear function. A can be country specific ($A_{i,t}$ or $A_{j,t}$) and also country-pair specific ($A_{ij,t}$).
- $\delta_{ij,t}$ is function of variable Z where $G(\cdot)$ is linear function. Z can be country specific ($Z_{i,t}$ or $Z_{j,t}$) and also country-pair specific ($Z_{ij,t}$).

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Econometric Specifications

- If we keep only $X_{ij,t}$ in the left-hand-side and assume additive error structure, we have following estimation equation.

$$X_{ij,t} = (1 - \delta_{ij,t})X_{ij,t-1} + \delta_{ij,t}X^*_{ij,t} + \mu_{ij} + \lambda_t + \nu_{ij,t}$$

- We further assume that the adjustment speed is the function of trade policy (trade barrier).

$$\delta_{ij,t} = G(Z) = d_0 + d_{RTA}RTA_{ij,t} + d_{MFN}MFN_{j,t} + \epsilon^{\delta}$$

- $RTA_{ij,t}$ is a binary variable where $RTA_{ij,t} = 1$ if a country pair ij shares regional trade agreement. It is based on the official clarification of WTO.
- $AppT_{j,t}$ is weighted mean of applied tariffs of destination country provided by UNCTAD (based on SITC Rev.3).

Econometric Specifications

$$X^*_{ij,t} = F(A) = b_0 + b_1 Y_{i,t} + b_2 Y_{j,t} + b_3 Dist_{ij} + b_4 Lang_{ij} \\ + b_5 Colony_{ij} + b_6 Contig_{ij} + \epsilon^g$$

- By assuming that $X^*_{ij,t}$ is not the function of trade policy, we can interpret $X^*_{ij,t}$ as the predicted level of trade flow under free trade.
- $Y_{i,t}$ and $Y_{j,t}$ are logarithmic values of GDP for country i and j, respectively.
- $Dist_{ij,t}$ is log of weighted bilateral distance between country i and country j in kilometer.
- $Lang_{ij,t}$ is binary variable which indicates whether both countries at each pair share the same official (or primary) language.
- $Colony_{ij,t} = 1$ if a country pair ij has colonial relationship. $Colony_{ij,t} = 0$ otherwise.
- $Contig_{ij,t}$ is a binary variable who has value of 1 when two countries are geographically contiguous.

Nonlinearity and Endogeneity

$$X_{ij,t} = (1 - \delta_{ij,t})X_{ij,t-1} + \delta_{ij,t}X^*_{ij,t} + \mu_{ij} + \lambda_t + \nu_{ij,t}$$

- The interaction term between $X^*_{ij,t}$ and $\delta_{ij,t}$ will make the nonlinearity in terms of coefficients by multiplying coefficients in $F(\cdot)$ and $G(\cdot)$ each other.
- Another important issue in this equation is the endogeneity caused by the lagged dependent variable $X_{ij,t-1}$. Therefore, we will need to handle this endogeneity while handling two-way fixed effects.
- We are using $X_{ij,t-2}$ and consequent interaction terms as instrumental variables (Anderson and Hsiao (1982)'s IV). Instrumental variable is implemented after the first difference transformation. (Nonlinear 2SLS)

Zero Trade Flow (Sample Selection)

$$X_{ij,t} = (1 - \delta_{ij,t})X_{ij,t-1} + \delta_{ij,t}X^*_{ij,t} + \hat{m}_{ij,t} + \mu_{ij} + \lambda_t + \nu_{ij,t}$$

- Zero (missing) trade flows can generate sample selection issues : In case of CEPII BACI's tradeflow during 2003-2019, missing trade flows account for 45 percents of total possible bilateral pairs.
- Al-Sadoon, Jimenez-Martin, and Labeaga (2019) suggest simple methods for consistent estimation of dynamic panel data sample selection models.
- Year-by-year probit models for computing univariate correction term (Heckman's lambda $\hat{m}_{ij,t}$).
- Variables which are not included in the main gravity estimation are required for the first step probit estimation (Cost of business start-up procedures, percent of GNI per capita, World Bank).

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Data

- Gravity variables : CEPII
- Trade flow : CEPII BACI
  (all-product aggregates and manufactured-product aggregates)
- Applied tariff : UNCTAD
- Unbalanced panel data of 203 origins and 203 destinations
- Sample period : 2003 - 2019

Data

Table: Descriptive Statistics, original data (2003 - 2019)

Variable	Mean	Std. Dev.	Min.	Max.	N
$X_{ij,t}$ (BACI)	8.570	3.964	-6.907	20.031	288,575
$X_{ij,t}$ (BACI, manu)	8.172	4.003	-6.907	20.026	285,892
$Y_{i,t}$	17.836	2.228	9.810	23.785	288,575
$Y_{j,t}$	18.215	2.190	11.684	23.785	288,575
$RTA_{ij,t}$	0.182	0.386	0	1	288,575
$AppT_{j,t}$	5.170	7.911	0	421.5	288,575
$Dist_{ij,t}$	8.624	0.846	3.135	9.895	288,575
$Language_{ij,t}$	0.143	0.350	0	1	288,575
$Colonial_{ij,t}$	0.015	0.125	0	1	288,575
$Contiguity_{ij,t}$	0.023	0.150	0	1	288,575

$X_{ij,t}$, $Dist_{ij,t}$ and GDP ($Y_{i,t}$, $Y_{j,t}$) went through logarithmic transformation.

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Estimation Results

Table: Nonlinear 2SLS : Not Corrected Zero Flows. All product aggregate, BACI

	Coefficient	Std. err.	z	P>z
d_0	0.782***	0.012	60.80	0.000
d_{RTA}	-0.087***	0.032	-2.71	0.007
d_{AppT}	0.001	0.001	1.02	0.308
b_0	11.276	20.997	0.54	0.591
$b_{Y,origin}$	0.409***	0.0418	9.79	0.000
$b_{Y,dest}$	0.499***	0.042	11.87	0.000
b_{Dist}	-2.773	2.442	-1.14	0.256
b_{Lang}	46.387**	22.809	2.03	0.042
b_{Col}	1.244	19.905	0.06	0.950
b_{Cont}	32.537	22.761	1.43	0.153

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, obs 288,575

AR(1) p-value : 0.000

AR(2) p-value : 0.155

Estimation Results

Table: Nonlinear 2SLS : Corrected Zero Flows. All product aggregate, BACI

	Coefficient	Std. err.	z	P>z
d_0	0.780***	0.010	71.17	0.000
d_{RTA}	0.087	0.0982	0.89	0.374
d_{AppT}	-0.0003	0.0003	-1.22	0.221
b_0	18.367	24.556	0.75	0.454
$b_{Y,origin}$	0.371***	0.056	6.55	0.000
$b_{Y,dest}$	0.450***	0.054	8.20	0.000
b_{Dist}	-2.300	2.603	-0.88	0.377
b_{Lang}	-52.776	62.135	-0.85	0.396
b_{Col}	12.679	22.353	0.57	0.571
b_{Cont}	8.640	23.748	0.36	0.716

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, obs : 248,899

AR(1) p-value : 0.000

AR(2) p-value : 0.186

Estimation Results

Table: Nonlinear 2SLS : Not Corrected Zero Flows. Manufacturing product aggregate, BACI

	Coefficient	Std. err.	z	P>z
d_0	0.686***	0.039	17.61	0.000
d_{RTA}	-0.014	0.017	-0.83	0.408
d_{AppT}	0.019***	0.005	3.29	0.001
b_0	-10.130	8.576	-1.18	0.238
$b_{Y,origin}$	0.360***	0.040	8.92	0.000
$b_{Y,dest}$	0.600***	0.038	15.79	0.000
b_{Dist}	-0.063	0.974	-0.07	0.948
b_{Lang}	3.286	2.484	1.32	0.186
b_{Col}	14.167**	6.652	2.13	0.033
b_{Cont}	6.317*	3.323	1.90	0.057

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, obs : 282,115

AR(1) p-value : 0.000

AR(2) p-value : 0.126

Estimation Results

Table: Nonlinear 2SLS : Corrected Zero Flows.
Manufacturing product aggregate, BACI

	Coefficient	Std. err.	z	P>z
d_0	0.813***	0.009	82.10	0.000
d_{RTA}	0.094	0.098	0.95	0.340
d_{AppT}	-0.001	0.0009	-1.62	0.104
b_0	-1.057	15.032	-0.07	0.944
$b_{Y,origin}$	0.336***	0.055	6.10	0.000
$b_{Y,dest}$	0.512***	0.052	9.79	0.000
b_{Dist}	-0.210	1.820	-0.12	0.908
b_{Lang}	-33.997	33.685	-1.01	0.313
b_{Col}	3.502	12.384	0.28	0.777
b_{Cont}	-8.442	15.352	-0.55	0.582

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, obs : 243,509

AR(1) p-value : 0.000

AR(2) p-value : 0.167

Sample Mean of $\delta_{ij,t}$, All products

Table: Increasing sample mean of adjustment term

Sample Mean of $\delta_{ij,t}$, Manufacturing products

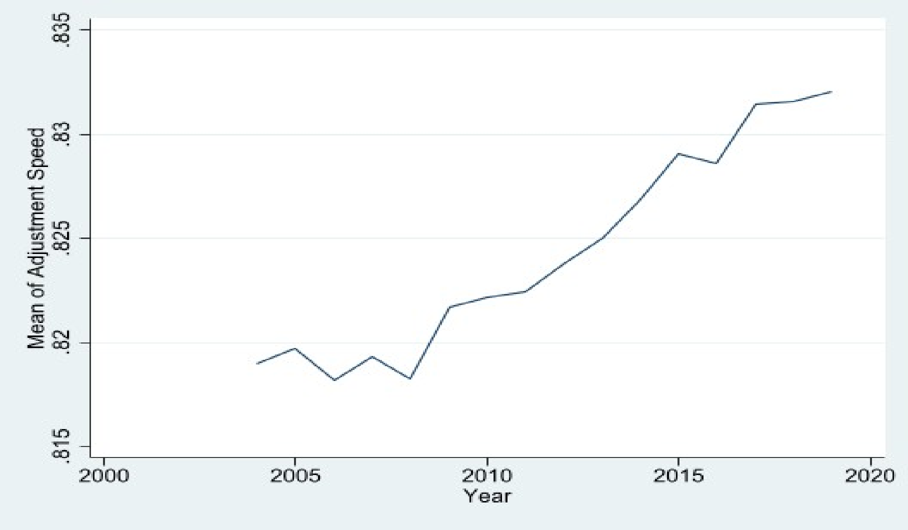

Table: Increasing sample mean of adjustment term

Dynamic Adjustment Framework

$$X_{ij,t} - X_{ij,t-1} = \delta_{ij,t}(X^*_{ij,t} - X_{ij,t-1})$$

- The main idea for this dynamic model is that the realized level of bilateral trade flow always tends to be different from the predicted level.
- The difference between realized level and predicted level is explained by adjustment speed term $\delta_{ij,t}$.
- As the overall trade barrier has been significantly lowered during the sample period, the gap between realized difference and predicted difference is explained less by FTA and tariff.

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