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. Discussion and Conclusions

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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 gives us empirical marginal effects consistent to theoretical predictions of gravity model.
- Decreasing values of adjustment speed indicates the increasing role of trade policy in the magnitude of bilateral trade flow.
- Free trade level of bilateral trade flow can be simultaneously expected within this framework.

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))

- However, recent developments in dynamic panel data estimation of gravity have not been able to quantify heterogeneous adjustment.

- Our framework quantifies the adjustment for each country-pair so that we can see the dynamic nature in deeper aspects.

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 realized 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 $X^*_{ij,t}$ and the realized level of bilateral trade flow $X_{ij,t}$.

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

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

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 optimal level.
- The difference between realized level and optimal levels is explained by adjustment speed.
- $\delta_{ij,t}$ 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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Nonlinearity

- 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.

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

- $RTA_{ij,t}$ 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.
- $MFN_{j,t}$ is simple average of MFN applied tariffs of destination country provided by UNCTAD (average of 5-digit MFN tariff level).

Nonlinearity

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

- 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

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

- 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. Instrumental variable is implemented after the first difference transformation. (Nonlinear 2SLS, Anderson and Hsiao (1982))

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Data

- Gravity variables : CEPII
- Trade flow : Comtrade Rev.1, IMF DOT and BACI
- MFN tariff level : UNCTAD

Data

Table: Descriptive Statistics, original data (1988 - 2018)

Variable	Mean	Std. Dev.	Min.	Max.	N
$X_{ij,t}$ (Comtrade)	7.427	4.387	-6.908	20.149	492270
$X_{ij,t}$ (IMF)	7.652	4.319	-6.908	20.106	474994
$X_{ij,t}$ (BACI)	7.557	4.338	-6.908	20.025	456408
$X_{ij,t}$ (BACI, manu)	7.212	4.324	-6.908	20.02	447738
$Y_{i,t}$	16.71	2.464	9.085	23.748	691308
$Y_{j,t}$	17.475	2.271	10.368	23.748	855104
$RTA_{ij,t}$	0.124	0.33	0	1	848235
$MFN_{j,t}$	9.208	6.771	0	113.988	884864
$Dist_{ij,t}$	8.762	0.815	0.545	9.891	769493
$Language_{ij,t}$	0.151	0.358	0	1	794019
$Colonial_{ij,t}$	0.011	0.105	0	1	848116
$Contiguity_{ij,t}$	0.014	0.119	0	1	782743

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

Data

Table: Descriptive Statistics, 4-year seasonality (1990 - 2018)

Variable	Mean	Std. Dev.	Min.	Max.	N
$X_{ij,t}$ (Comtrade)	7.396	4.431	-6.908	20.149	126976
$X_{ij,t}$ (IMF)	7.606	4.348	-6.908	20.106	124055
$X_{ij,t}$ (BACI)	7.529	4.36	-6.908	20.025	120121
$X_{ij,t}$ (BACI, manu)	7.189	4.343	-6.908	20.02	117879
$Y_{i,t}$	16.739	2.466	9.085	23.748	178963
$Y_{j,t}$	17.462	2.285	10.368	23.748	220224
$RTA_{ij,t}$	0.128	0.334	0	1	218604
$MFN_{j,t}$	9.231	6.985	0	82.78	227664
$Dist_{ij,t}$	8.759	0.812	0.545	9.891	198758
$Language_{ij,t}$	0.151	0.358	0	1	204866
$Colonial_{ij,t}$	0.011	0.105	0	1	218574
$Contiguity_{ij,t}$	0.015	0.12	0	1	201838

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Estimation Results

- The validity of $X_{ij,t-2}$ as instrumental variable is revealed at the serial correlation test of differenced error. (Arellano and Bond (1991))
- The differenced error should reject the AR(1) test while AR(2) test should not be rejected.
- When we used every year for estimation, this AR conditions were not satisfied regardless of the source of data (Comtrade, IMF DOT, and BACI)
- Only when we implemented seasonality data of every 4-year, we were able to make sure that the $X_{ij,t-2}$ is the proper IV.

Estimation Results

- Even when we implemented seasonality data of every 4-year, AR conditions are satisfied only when we restricted our information to the manufacturing.
- This is due to the fact that the dynamics of comparative advantage is stable in non-manufacturing industries. (Hanson, Lind, and Muendler (2018), Levchenko and Zhang (2016))
- Trade flow information including every industry includes stable dynamics especially in agricultural sector and natural resources sector.

Estimation Results

Table: Nonlinear 2SLS : Dynamic Gravity with Adjustment. 4-year seasonal data, manufacturing only (BACI)

	Coefficient	Std. err.	z	P>z
d_0	0.8337***	0.0206	40.32	0
d_{RTA}	-0.1201*	0.0720	-1.67	0.096
d_{MFN}	-0.0026	0.0016	-1.62	0.105
b_0	-10.0703	12.9037	-0.78	0.435
$b_{Y,origin}$	0.4672***	0.0377	12.37	0
$b_{Y,dest}$	0.9379***	0.0405	23.15	0
b_{Dist}	-1.2463	1.558	-0.8	0.424
b_{Lang}	42.9898*	25.5228	1.68	0.092
b_{Col}	-20.457	15.5420	-1.32	0.188
b_{Cont}	30.6846	38.5939	0.8	0.427

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Arellano-Bond's AR(1) statistics : (Chi(2)), 3639.091
- Arellano-Bond's AR(2) statistics : (Chi(2)), 1.132

Estimation Results

Table: Marginal Effect (M.E.) of each variable towards $X_{ij,t}$

Variable	Mean of M.E.	Std Dev of M.E.	Min of M.E.	Max of M.E.
$RTA_{ij,t}$	-0.3118	1.8813	-9.6576	3.5155
$MFN_{ij,t}$	-0.0069	0.04182	-0.2147	0.07816
$Y_{i,t}$	0.3667	0.0242	0.2886	0.38957
$Y_{j,t}$	0.7361	0.0486	0.5793	0.7819
$Dist_{ij}$	-0.9782	0.0646	-1.03911	-0.7698
$Lang_{ij}$	33.74	2.2310	26.5528	35.841
$Colony_{ij}$	-16.0565	1.0616	-17.0551	-12.6353
$Contig_{ij}$	24.0841	1.5924	18.9524	25.5820

Common Break of Korean Comparative Advantage with sectoral labor union

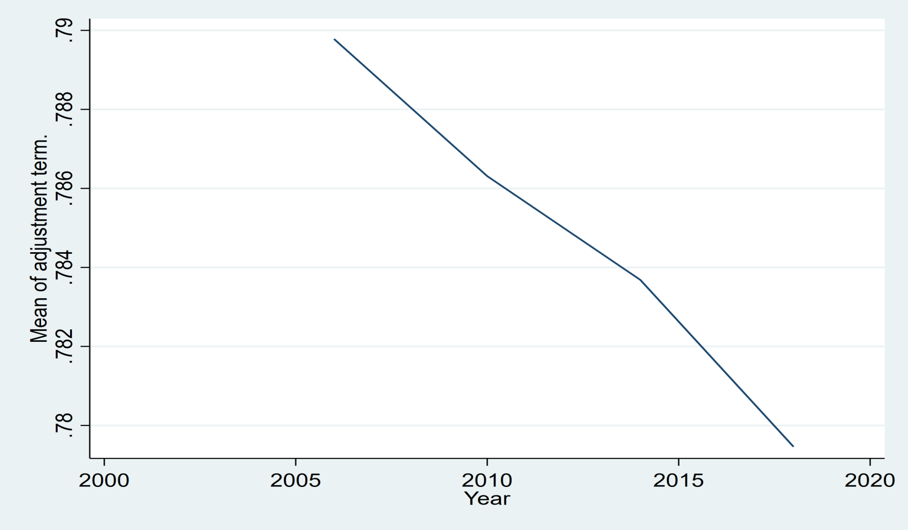

Table: First-difference common break estimator

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Discussion and Conclusion

- Decreasing value of $\delta_{ij,t}$ within (0,1) emphasizes the increasing role of trade policy in international trade. (The realized difference is getting smaller than the predicted difference.)
- As the adjustment term $\delta_{ij,t}$ is flexible across each country pair, we can make comparison analysis (such as OECD vs non-OECD, across different continents, democracies vs non-democracies, and so on)
- Due to the serial correlation issue related to the dynamics of comparative advantage, results might be sensitive to the scope of sector that researcher decides.

Thank you very much!

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