Graduate Trade (II): ECON 8433

Sergey Nigai
University of Colorado Boulder
Fall Semester 2020

Plan

Week	Topic
Week 1	Introduction to Structural Gravity Equation
Week 2	Calibration and Estimation
Week 3	Mapping Models to the Data
Week 4	Designing Counterfactual Experiments in General Equilibrium
Week 5	Presentations (I) and Catch-up
Week 6	Heterogeneous Firms (I)
Week 7	Heterogeneous Firms (II)
Week 8	Ricardian Models
Week 9	Multi-Sector Models
Week 10	Global Value Chains
Week 11	Presentations (II) and Catch-up
Week 12	Extensions: Demand Side
Week 13	Extensions: Supply Side
Week 14	Extensions: Migration and Geography
Week 15	Presentations (III) and Catch-up

Plan

Week	Topic
Week 1	Introduction to Structural Gravity Equation
Week 2	Calibration and Estimation
Week 3	Mapping Models to the Data
Week 4	Designing Counterfactual Experiments in General Equilibrium
Week 5	Presentations (I) and Catch-up
Week 6	Heterogeneous Firms (I)
Week 7	Heterogeneous Firms (II)
Week 8	Ricardian Models
Week 9	Multi-Sector Models
Week 10	Global Value Chains
Week 11	Presentations (II) and Catch-up
Week 12	Extensions: Demand Side
Week 13	Extensions: Supply Side
Week 14	Extensions: Migration and Geography
Week 15	Presentations (III) and Catch-up

Trade Brown Bag

- Very important to attend for those who even remotely consider doing trade as the main/secondary field
- Friday, 1pm-2:30pm
- Send email to Jeronimo Carballo to be included in the email list

FSOLVE, FMINUNC, and FMINSEARCH

We can use FSOLVE, FMINUNC and FMINSEARCH to solve the Armington model:

$$\begin{aligned}
Y_j &= w_j L_j \\
P_j &= \left(\sum_{i \in S} a_{ij} A_i^{\sigma-1} \left(\tau_{ij} w_i \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \\
X_{ij} &= \left(A_i^{\sigma-1} w_i^{1-\sigma} \right) \times \left(a_{ij} \tau_{ij}^{1-\sigma} \right) \times \left(Y_j P_j^{\sigma-1} \right) \\
w_i &= \sum_{j \in S} X_{ij} / L_i
\end{aligned}$$

Estimating Gravity Models

Estimating Gravity

In the Armington model:

$$X_{ij} = \left(A_i^{\sigma-1} w_i^{1-\sigma}\right) \times \left(a_{ij}\tau_{ij}^{1-\sigma}\right) \times \left(Y_j P_j^{\sigma-1}\right) \qquad (1)$$

Before estimation we have to log-linearize it as

$$\ln X_{ij} = (\sigma-1)\left(\ln A_i - \ln w_i\right) + \left(\ln a_{ij} - (\sigma-1)\ln \tau_{ij}\right) + \left(\ln Y_j + (\sigma-1)\ln P_j\right) \qquad (2)$$

Why would we want to estimate (2)?

Estimating Gravity

The main reason for estimating the gravity equation in (2) is to test the theory!

- We generally have very good data on X_{ij}
- In principle, we could plug in observations on σ, A_i, w_i, a_{ij}, τ_{ij}, Y_j and P_j in the equation and predict $\widehat{X}_{ij}$
- Define a measure of how well $\widehat{X}_{ij}$ explains X_{ij} (say R^2) and judge whether the Armington gravity works

Unfortunately, more often than not, we do not use estimation for confirming/disproving theories. Why?

Estimating Gravity

Fundamental Limitations

- *Fundamentally* unobservable variables: σ, A_i, a_{ij}, τ_{ij}
- Variables observed (potentially with error): w_i and P_j.

Unless we can observe σ, A_i, a_{ij},and τ_{ij}, we cannot directly test the Armington model!

Estimating Gravity

Isomorphism

You can argue that we can replace $A_i^{\sigma-1} w_i^{1-\sigma}$ with a set of exporter fixed effects and find an appropriate proxies for a_{ij} and τ_{ij} such as distance to test the Armington model.

- We should keep in mind that many trade models lead to structural gravity equation such that the estimation equation is isomorphic.
- If we estimate gravity using fixed effects we cannot conclude from high R^2 that the Armington model fits the data!

Estimating Gravity

Disentangling collinear variables

Using fixed effects is also problematic because it creates challenges for disentangling isomorphic variables.

- It would not be straightforward to separate A_i and w_i from the estimates of the exporter fixed effects

The same is generally true when we try to use proxies.

- While distance between i and j should be a relatively good proxy for τ_{ij} it may also be correlated with a_{ij}. Is there a way to disentangle the two?

Estimating Gravity

Instead of *fitting* theories to the data, we use the data to parameterize the models. This is not an innocuous thing to do because we make the following implicit assumptions:

- We assume that the data generating process (DGP) is (almost) perfectly governed by the theory that we have in mind
- Whether or not the above is true, we force the data to adhere to the theoretical constraints of the model
- We then can use the data to estimate our parameters of interest

Structural Estimation

Recall our equation for trade flows:

$$X_{ij} = \left(A_i^{\sigma-1} w_i^{1-\sigma}\right) \times \left(a_{ij}\tau_{ij}^{1-\sigma}\right) \times \left(Y_j P_j^{\sigma-1}\right),$$

and the trade balance condition:

$$Y_i = \sum_k X_{ij} = \sum_k \left(A_i^{\sigma-1} w_i^{1-\sigma}\right) \times \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right)$$

or equivalently:

$$Y_i = \sum_k \left(A_i^{\sigma-1} w_i^{1-\sigma}\right) \times \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right)$$

which means:

$$\left(A_i^{\sigma-1} w_i^{1-\sigma}\right) = \frac{Y_i}{\sum_k \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right)}$$

Structural Estimation

Substitute the expression for $\left(A_i^{\sigma-1} w_i^{1-\sigma}\right)$ back into the gravity equation to get:

$$X_{ij} = \frac{Y_i}{\sum_k \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right)} \times \left(a_{ij}\tau_{ij}^{1-\sigma}\right) \times \left(Y_j P_j^{\sigma-1}\right)$$

To simplify notation create the following auxiliary variables:

$$\Pi_j = P_j^{1-\sigma}; \qquad K_{ij} = \left(a_{ij}\tau_{ij}^{1-\sigma}\right); \qquad \Phi_i = \sum_k \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right);$$

Then, the following is the "traditional" structural gravity equation:

$$X_{ij} = \frac{Y_i}{\Phi_i} \times K_{ij} \times \frac{Y_j}{\Pi_j}$$

Structural vs. Reduced Form

It is customary to proxy for K_{ij} using bilaterally varying variables supposedly related to trade costs. For example, you could assume the following relationship:

$$\ln K_{ij} = \alpha \ln(distance_{ij}) + \beta \ln(border_{ij})$$

We can now estimate the gravity equation!

Structural vs. Reduced Form

A naive gravity equation looks as follows:

$$\ln X_{ij} = const + \gamma_1 \ln Y_i + \gamma_2 \ln(distance_{ij}) + \gamma_3 \ln(border_{ij}) + \gamma_4 \ln Y_j + \epsilon_{ij}$$

Why is this reduced form problematic?

Structural vs. Reduced Form

- McCallum (1995) estimated this equation using data for 10 Canadian provinces and 30 states to quantify the effect of national borders
- He found that the US-Canadian border led to trade between Canadian provinces that is a factor 22 (2,200 percent) times trade between U.S. states and Canadian provinces

McCallum did not take into account the multilateral resistance terms (MRT's): Φ_i and Π_i!

- When Anderson and van Wincoop (2003) re-estimated the same equation taking into account Φ_i and Π_i, they found that the border decreased trade by 20% to 50%

Structural Estimation: Approaches

Structural Estimation

- Structural estimation always involves a very strong assumption that your model (almost) perfectly describes true DGP
- If you structurally estimate the Armington model, you must assume that there are no outside forces, except for purely stochastic error terms
- You also must take your model literally! You must use the exact functional forms predicted by the model

Structural Estimation: Fixed Effects

Log-linearize the structural gravity equation:

$$X_{ij} = \frac{Y_i}{\Phi_i} \times K_{ij} \times \frac{Y_j}{\Pi_j}$$

Parameterize K_{ij} and replace i-specific and j-specific variables with the appropriate fixed effects:

$$\ln X_{ij} = exp_i + \alpha \ln d_{ij} + imp_j + \epsilon_{ij}$$

Then, the following must hold:

$$exp(\widehat{exp_i}) = \frac{Y_i}{\Phi_i}; \;\; exp(\widehat{imp_i}) = \frac{Y_i}{\Pi_i}; \;\; exp(\widehat{d_{ij}^{\alpha}}) = K_{ij}$$

Structural Estimation: Fixed Effects

Plug in the expressions for Φ_i, P_i and K_{ij} to get the following system of equations:

$$\begin{aligned} exp(\widehat{exp_i}) &= \frac{Y_i}{\sum_k \left(a_{ik}\tau_{ik}^{1-\sigma}\right) \times \left(Y_k P_k^{\sigma-1}\right)} \\ exp(\widehat{imp_i}) &= Y_i P_i^{\sigma-1} \\ exp(\widehat{d_{ij}^{\alpha}}) &= a_{ij}\tau_{ij}^{1-\sigma} \end{aligned}$$

Recall that we need A_i, L_i, σ, τ_{ij}, and a_{ij}. So what has the structural estimation bought us?