Firm-level Gravity with Fixed Effects *

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— Preliminary Draft —

Abstract

This paper introduces an new method for estimating gravity equations at the firm level by leveraging both firm and country-level trade data. By constructing a flexible estimation strategy that accounts for firm-level and country-level characteristics, in particular for multilateral resistances at origin and destination, we offer a novel approach to measure the impact of policy changes such as tariffs, sanctions, etc., on trade flows. Through a series of simulations and replications of established firm-level gravity estimations, we validate the robustness of our methodology. Our findings not only contribute to the empirical trade literature by providing a more precise analytical tool but also have significant policy implications, highlighting the heterogeneous effects of economic policies on firms within and across countries.

Keywords: Firm-level, Gravity Model, Fixed effects, Large data
JEL Codes: F10, F13, F14, C51, C23

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1 Introduction

A firm's exports to a foreign country depends on the importing country's demand. Existing studies using the gravity framework in international trade neglect this very simple truism by not controlling properly for demand in estimations. We propose a novel but equally simple way of addressing this issue by combining firm- and country-level trade data.

These papers focus on the application of gravity models to understand trade flows and the impact of knowledge on trade: Keller and Yeaple (2013), Morales et al. (2019), Chaney (2008), Chaney (2018)

This collection examines firm-level data to assess productivity, with some focusing on multinational corporations' influence on trade: Crozet et al. (2012), Craviona and Ramonda (2023), Garg Shresth et al. (2023), Lee et al. (2023), Wang (2021)

These papers delve into the role of spatial and topographical elements in shaping the patterns and dynamics of international trade: Rossi-Hansberg (2005), Allen and Arkolakis (2014), Defever et al. (2015), Békés and Muraközy (2012)

In this group, the focus is on intrafirm trade dynamics and the characteristics of high-end variety exporters defying standard trade models: Irarrazabal et al. (2013), Flach and Unger (2022), Martin and Mayneris (2015)

These papers explore the nuances of trade elasticity and the existence of lexicographic biases in international trade patterns: Bas et al. (2017), Cheng et al. (2020)

These works explore how networks influence trade and the historical weight of European cultural integration in economic contexts: Grosjean (2011), Bastos and Silva (2012)

The remainder of this paper is as follows: We sketch a simple exporting model at the firm and country level in section 2. We then show how this model can (and should) be estimated using trade data comprising of firm and country-level information in section 3. We show the procedure's properties using simulated data in section 4, before applying the procedure to several well-known examples of firm-level gravity estimations in section 5. Section 6 concludes.

2 Model for exports at the firm and country level

We will now outline a simplified model of international trade that forms the theoretical basis for estimating the trade effects of the embargo.

Demand in destination country d for a product k at time t is governed by a utility function

that aggregates over the set Θ_d of all available varieties i,[1] such that

$$U_{dkt} = \left(\int_{i \in \Theta_d} (a_{idkt}\ q_{idkt})^{\frac{\sigma-1}{\sigma}}\ di \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

The elasticity of substitution is $\sigma > 1$, q_{idkt} is the quantity of variety i consumed in country d, and a_{idkt} is a demand shifter.[2] The demand in market d for a firm i at time t is then given by

$$x_{idkt} = \left(\frac{p_{ipt}}{a_{idkt}} \right)^{1-\sigma} A_{dkt} \tau_{odkt}^{1-\sigma}. \tag{2}$$

A_{dkt} characterizes country d's overall propensity to import product k from all countries, i.e., total expenditure on product k and multilateral resistance. The term p_{ikt} is the factory gate price charged by firm i irrespective of the buyer. Each firm i is located in a country o such that ad-valorem trade cost between origin country o and destination country d for product k are described by τ_{odkt}.

Let $a_{idkt} = (\psi_{idk} e^{\epsilon_{idkt}})^{-1}$, where ψ_{idk} summarizes firm i's time-invariant non-price determinants of competitiveness on market d, and ϵ_{idkt} is a random shock. Rearranging equation 2, we obtain firm exports as

$$x_{idkt} = (p_{ikt} \psi_{idk} e^{\epsilon_{idkt}})^{1-\sigma} A_{dkt} \tau_{odkt}^{1-\sigma}. \tag{3}$$

Summing over all firms in a given origin country, country-level exports from country o to country d of product k at time t are expressed by

$$x_{odkt} = \sum_{i \in o} x_{idkt} = N_{okt} A_{dkt} \left(\bar{\psi}_{odk} \tau_{odkt} \right)^{1-\sigma} e^{\epsilon_{odkt}}. \tag{4}$$

N_{okt} summarizes exporter $\times$ product $\times$ time-specific effects of firms from country o producing k at time t, e.g. the number of firms, their total sales, and the country's multilateral resistance. $\bar{\psi}_{odk}$ is an aggregate of determinants of the competitiveness of firms from country o in the country d, and ϵ_{odkt} is an error term.

Finally, assume that sanctions affect trade through changes in the trade costs so that $\tau_{odkt} = \tilde{\tau}_{odkt} e^{\delta_k S_{odkt}}$, where S_{odkt} is an indicator for a sanctions measure in place, δ_k the product-specific sanctions effect, and $\tilde{\tau}_{odkt}$ other standard trade costs.

[1] A variety i is produced by a single firm, which hence can also be indexed i.

[2] a_{idkt} captures firm-level characteristics, such as the quality of the offered variety i as perceived by consumers in country d, but also its network with purchasers in market d.

3 Estimation with firm *and* country-level data

This model setup allows us to flexibly estimate a gravity equation at the firm or at the country level. It also allows us to do both simultaneously: Combining a firm-level dataset for one country and country-level data without this country enables us to include the most flexible sets of fixed effects, even for firm-level estimations. Without including the country-level data, the destination × product × time fixed effect, Γ_{dkt}, would be collinear to the variable of interest, S_{odkt}, as the origin would always be the same. Adding multiple origin countries with country-level data solves this problem.

Therefore we can estimate equation (3) and (4) *jointly* as

$$X_{\{i,o\}dkt} = \exp\left(\Gamma_{\{i,o\}kt} + \Gamma_{dkt} + \Gamma_{\{i,o\}dkm} + \delta_k S_{odkt}\right) \tag{5}$$

where $X_{\{i,o\}dkt}$ are flows from either firm i or country o to country d of product k at time t, $\Gamma_{\{i,o\}kt}$ is an firm- or country-level origin × product × time fixed effect, Γ_{dkt} a destination × product × time fixed effect, and $\Gamma_{\{i,o\}dk}$ a firm- or country-level bilateral origin × destination × product × month fixed effect. δ_k measures the (average) effect of a sanctions measure, as indicated by the dummy variable S_{odkt}. Hence, combining firm-level and country-level trade data allows us to estimate the firm-level effects of sanctions while all three sets of fixed effects.

4 Simulation

To be added.

5 Replication

5.1 Extended Gravity (Morales, Sheu and Zahler, 2019)

To be added.

5.2 Quality Upgrading (Crozet, Head and Mayer, 2012)

To be added.

5.3 Sanctions Effects (Aytun, Hinz and Özgüzel, 2024)

To be added.

Model:	(1) Two-way	(2) Two-way with est. FE	(3) Three-way	(4) Three-way with global data
Embargo × imposition period	-14.369***	-12.938***	-13.626***	-13.324***
	(0.674)	(0.731)	(1.081)	(0.700)
Embargo × lifting period	-0.700***	-0.175	-0.151	0.020
	(0.206)	(0.148)	(0.241)	(0.224)
Diversion × imposition period	0.083	0.173	0.060	0.673***
	(0.130)	(0.119)	(0.167)	(0.191)
Diversion × lifting period	-0.235*	-0.049	-0.097	0.246
	(0.134)	(0.108)	(0.178)	(0.166)
Circumvention × imposition period	-0.443***	-0.407***	0.081	-0.413*
	(0.142)	(0.139)	(0.210)	(0.221)
Circumvention × lifting period	-0.209	-0.105	0.508**	-0.163
	(0.141)	(0.132)	(0.211)	(0.235)
Est. destination × product × time FE		0.857***		
		(0.047)		
Russia embargo × imposition period				-4.677***
				(0.264)
Fixed-effects				
Observations	1,185,212	1,114,179	1,179,861	13,001,185
Origin × product × time	Yes	Yes	Yes	Yes
Origin × destination × product × month	Yes	Yes	Yes	Yes
Destination × time	No	No	Yes	No
Destination × product × time	No	No	No	Yes

Table 1: Replication of Aytun et al. (2024).

6 Conclusion

To be added.

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A Robustness Checks