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Gravity without Apology: The Science of Elasticities, Distance, and Trade

Hotel "Grand Villa Argentina"

Dubrovnik

June 14 – 16, 2019

Draft version

Please do not quote

CROATIAN NATIONAL BANK

Gravity without Apology: The Science of Elasticities, Distance, and Trade

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25th Dubrovnik Economic Conference
June 14, 2019

Introduction: Gravity and International Trade

- Gravity: The value of trade declines with distance
- One of the great successes of modern economics
- Gravity in trade is both *fact* and *theory*

  – Like evolution: Gould (1981)

- Though this is not widely known by economists outside trade
- And "anti-gravity" continues to have popular appeal

Gravity in the News

FINANCIAL TIMES

TUESDAY 19 APRIL 2016 — WORLD BUSINESS NEWSPAPER — UK £2.70 Channel Islands £3.00; Republic of Ireland €3.00

Merkel's comic error Europe must fight for freedom of speech — GIDEON RACHMAN, PAGE 13

Problem child Counting the global cost of El Niño — BIG READ, PAGE 11

Executive pay The biggest block to trust in business — ANDREW HILL, PAGE 14

Treasury's grim forecasts spark fury from Tory Brexit rebels

● Osborne seeks to demolish economic case for Out ● Gove to launch stinging response

GEORGE PARKER — POLITICAL EDITOR

George Osborne's attempt to conquer the economic battlefield on Brexit with dire Treasury predictions of the damage leaving the EU would inflict on the country has brought the deep split on Europe within the Conservative party into the heart of government.

Justice secretary Michael Gove, the cabinet's leading Leave campaigner, will today accuse the pro-EU campaign of treating voters "like children" in a furious response to Mr Osborne's declaration that pro-Brexit advocates were "economically illiterate".

In the most significant day of the EU referendum campaign so far, Mr Osborne sought to destroy the economic arguments for Brexit in a 200-page Treasury analysis of the impact of a Leave vote.

This week is seen in Number 10 as crucial, with Barack Obama arriving in London later in the week with an expected message that the US would prefer the UK to stay in the EU.

The Treasury paper's main scenario claimed that an exit would over the medium term lead to falling trade and put a £36bn annual dent in the public finances, equivalent to 8p on the basic rate of income tax.

Over 15 years the economy would be 6.2 per cent smaller than would have been the case, costing each household £4,300 a year. The paper was denounced by senior Tory MP Bernard Jenkin as "highly tendentious".

In a stinging backlash, Mr Gove, who counts himself as a friend of the chancellor and David Cameron, will accuse the Remain camp — and by extension the prime minister — of "treating people like mere children, capable of being frightened into obedience by conjuring up new bogeymen every night".

Mr Osborne will in coming weeks publish a second paper outlining the "short-term economic shock" of a Brexit, intended to bring the risks to household budgets into sharp relief ahead of the June 23 vote. The Treasury is expected to warn that a Brexit vote would be accompanied by a sharp drop in the pound, causing rising inflation and the prospect of higher interest rates.

With some polls showing the Remain and Leave camps running neck-and-neck, Mr Cameron hopes to shift votes with a relentless focus on the alleged threat to growth and jobs of a Brexit.

But Mr Gove will highlight in a speech that the Treasury's analysis paper was built on the assumption by the Office for Budget Responsibility that immigration would continue to rise well above the government's 100,000 annual target. "The report by the Treasury is an official admission from the In campaign that if we vote to stay in the EU then immigration will continue to increase by hundreds of thousands a year," he will say.

However, the Leave campaign cannot agree on what exactly "out" should look like. Boris Johnson, London's mayor, had floated the idea that Britain could have a Canada-style bilateral trade deal with the EU. He suggested yesterday it could be a looser deal based on World Trade Organisation rules — a scenario the Treasury said would reduce national income by 9.5 per cent.

Britain in Europe pages 2 & 3
Editorial Comment page 12
Janan Ganesh page 13
Smart Money page 32

The chancellor said pro-Brexit advocates were 'economically illiterate'

Three Treasury scenarios
Changes in UK GDP by 2030

WTO membership only: -9.5%

Negotiated bilateral agreement (like Canada): -6.2%

Membership of EEA (like Norway): -3.8%

... and the key equation

The Treasury's formula for calculating trade values between countries

$$\ln(T_{ijt}) = \alpha_{ij} + \gamma_t + \alpha_1 \ln(Y_{it} * Y_{jt}) + \alpha_2 \ln(POP_{it} * POP_{jt}) + \alpha_3 \ln(DIST_{ij}) + \alpha_4 COMLANG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 BORDER_{ij} + \varepsilon_{ijt}$$

Briefing

▶ **Big companies look outside for a leader** Big UK companies are breaking with global peers and hiring more chiefs from outside than ever. Last year, 58 per cent came from another group, versus 23 per cent globally.— PAGE 17; LOMBARD, PAGE 22

▶ **Britons own 11% of world's superyachts** A survey has revealed that after a rise in demand in recent years, more than one in 10 superyachts are owned by Britons, the second-largest fleet in the world. The US accounts for 33 per cent.— PAGE 4

▶ **Watchdog sees 80% jump in challenges** The financial regulator has seen an 80 per cent increase in the number of its adjudications that are challenged, with the rise due mostly to Libor and forex rigging, and consumer credit cases.— PAGE 22

▶ **King quits Villa board after two months** Former governor of the Bank of England Mervyn King has resigned from the board of Premier League club Aston Villa — just two months after joining and two days after the club was relegated.— PAGE 17

▶ **Crude dips but recovers after talks fail** Brent was roughly flat after the failure of Doha talks aimed at an output freeze on Sunday but a serious sell-off was avoided. Meanwhile, Riyadh policy has a new voice.— PAGE 5; LEX, PAGE 16; MARKETS, PAGES 30-32

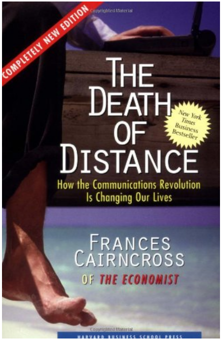
▶ **Buenos Aires ends 15-year debt exile** Argentina has secured one of the most anticipated comebacks, ending 15 years in exile with a debt sale that attracted bids of more than $50bn. Early signs put 10-year debt yield at under 8 per cent.— PAGE 30

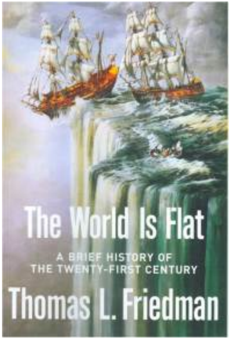
▶ **Israeli soldier charged over killing** An Israeli soldier has been charged with manslaughter over the shooting of an unarmed Palestinian assailant as he lay on the ground, the first case of its kind in more than a decade.— PAGE 6

Datawatch

Counterfeit and pirated goods represented a value of more than $460bn in 2013, similar to the GDP of Austria. Almost 20 per cent of the value of seized products refers to intellectual property of holders registered in the US

Anti-Gravity





"Today, we stand on the verge of an unprecedented ability to liberate global trade for the benefit of our whole planet with technological advances dissolving away the barriers of time and distance. It is potentially the beginning of what I might call 'post geography trading world' where we are much less restricted in having to find partners who are physically close to us."

– Liam Fox, UK Minister for International Trade, Sept. 2016

This Paper

- Review the evidence for gravity
- Introduce some simple ways of understanding CES gravity
- Note some problems with CES
- Sketch some alternatives
- Background: Brexit ...
  - 1973, January 1: UK joined EEC, later the European Union (EU)
  - 2016, June 23: UK referendum: Vote to leave EU 51.89% to 48.11%
  - 2017, March 29: UK invoked Article 50 of EU Treaty, starting a two-year process of withdrawal
  - 2019, March 29: Deadline extended to October 31
  - 2019, May 29: Still unclear whether UK will remain in EU, or leave, with or without a deal

Economics of Brexit

- Many studies of the trade effects of Brexit
  - Predominantly using the gravity model
    - Dhingra et al. (2017), Sampson (2017)
    - Brakman, Garretsen, and Kohl (2018)
    - Mayer, Vicard, and Zignago (2019)
  - We ignore work on other economic aspects of Brexit
    - Davies and Studnicka (2018): Stock-market response
    - McGrattan and Waddle (2018): Impact on foreign investment
    - Alabrese, Becker, Fetzer, and Novy (2019): Determinants of voting
    - O'Rourke (2019): Historical context

Economics of Brexit: Professional Consensus

- Professional consensus: Three Iron Laws of the Economics of Brexit
  - Focusing on trade in goods ...
  - ... ignoring transitional problems ...
  - ... and macro policy responses

1. *The only good Brexit is a dead Brexit*
2. *The harder the Brexit the higher the economic costs*
3. *Even a hard Brexit will not have "very" large costs*
   - 2% of GDP if soft, 6+% of GDP if hard
   - Compare: UK spent 7.26% of GDP on NHS in 2016/17

Background

Carrère, C., M. Mrázová, and J. P. Neary (2019): "Subconvex Gravity," in preparation.

Lawless, M., J. P. Neary, and Z. Studnicka (2019): "Explaining the Volume of South-North Trade in Ireland: Gravity and Firms from the Good Friday Agreement to Brexit," in preparation.

Mrázová, M., and J. P. Neary (2017): "Not so Demanding: Demand Structure and Firm Behavior," *American Economic Review*, 107(12), 3835–3874.

Mrázová, M., and J. P. Neary (2019): "Selection Effects with Heterogeneous Firms," *Journal of the European Economic Association*, forthcoming.

Mrázová, M., and J. P. Neary (2019): "IO for Export(s)," Working Paper No. 868, Department of Economics, University of Oxford.

Maggi, G., M. Mrázová, and J. P. Neary (2018): "Choked by Red Tape? The Political Economy of Wasteful Trade Barriers," CEPR Discussion Paper No. 12985.

Outline

1. Gravity as Fact
2. Gravity as Theory
3. Gravity Anomalies
4. Subconvex Gravity
5. Conclusion

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The Gravity Equation: A Universal Tendency

- Overwhelming professional consensus that distance matters for trade
    - Head and Mayer (2014): review of 159 papers
        - Average preferred estimate of distance elasticity: -1.1
        - S.D. 0.41; median -1.14
- Not just geographical distance matters:
    - Common language, legal system, colonial origins, FTA membership, etc.
- Results below for distance elasticity of 2017 UK exports in line with the literature:
    - -0.752 (0.098): OLS, simple regression, $n = 181$
    - -1.441 (0.023): OLS, full controls, $n = 23,251$
    - -0.735 (0.034): OLS, $\ln(1 + V_{jk})$ as depvar, full controls, $n = 42,230$
    - -0.977 (0.021): PPML, full controls, $n = 42,230$

Gravity: Not Just for Trade in Goods

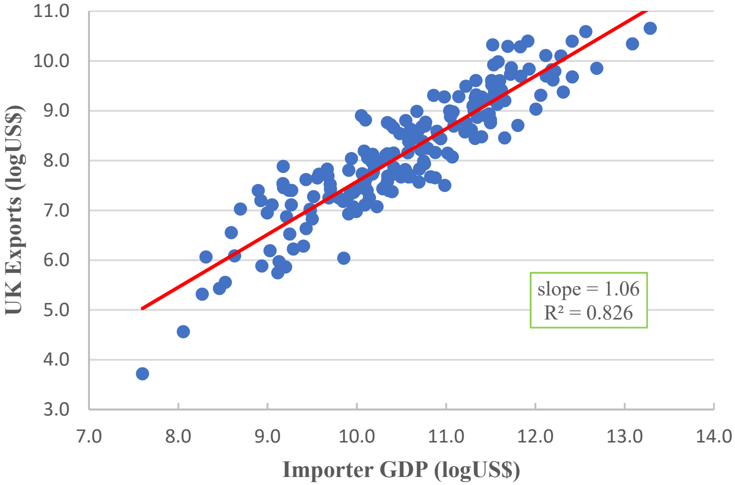
- Distance also matters (though less so on average) for:
  - Services trade: Kimura and Lee (2006)
  - FDI: Kleinert and Toubal (2010), Keller and Yeaple (2013)
  - Equities: Portes and Rey (2005)
  - eBay: Lendle, Olarreaga, Schropp, and Vézina (2016)
  - Google: Cowgill and Dorobantu (2012)
- And the distance coefficient for goods trade has not fallen over time
  - "The Mystery of the Missing Globalization"!
  - But: Not a mystery
  - Distance is relative

[Yotov (2012)]

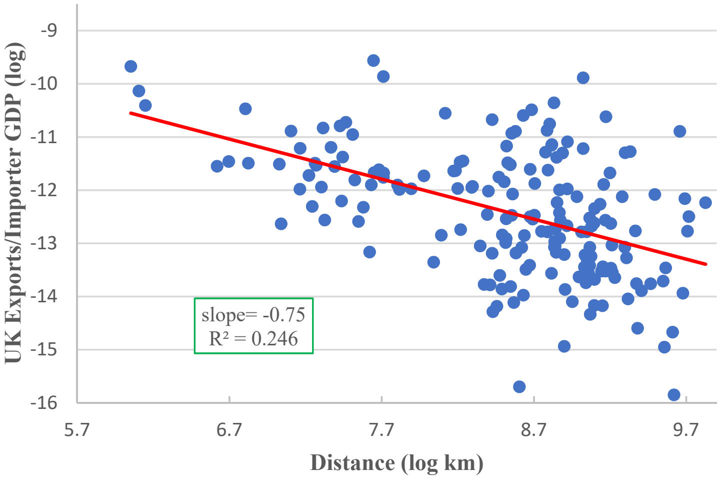
Data Sources, etc.

- Survey:
  - Head and Mayer (2014)
- Data: CEPII
  - http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8
- UK trade policy: UK Trade Policy Observatory
  - http://blogs.sussex.ac.uk/uktpo/
- EU trade agreements
  - http://ec.europa.eu/trade/policy/countries-and-regions/negotiations-and-agreements/

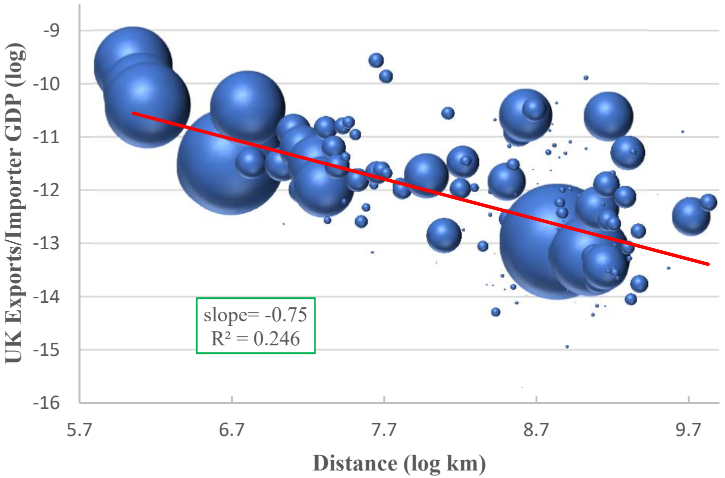
UK Exports and Importer GDP, 2017



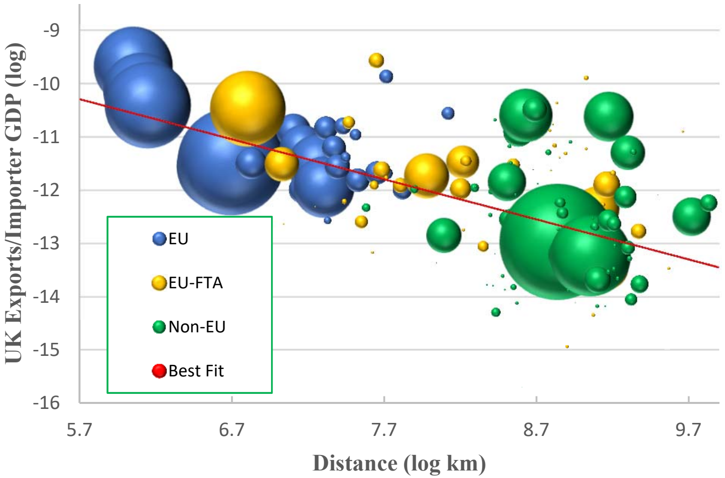
UK Exports/Importer GDP and Distance, 2017



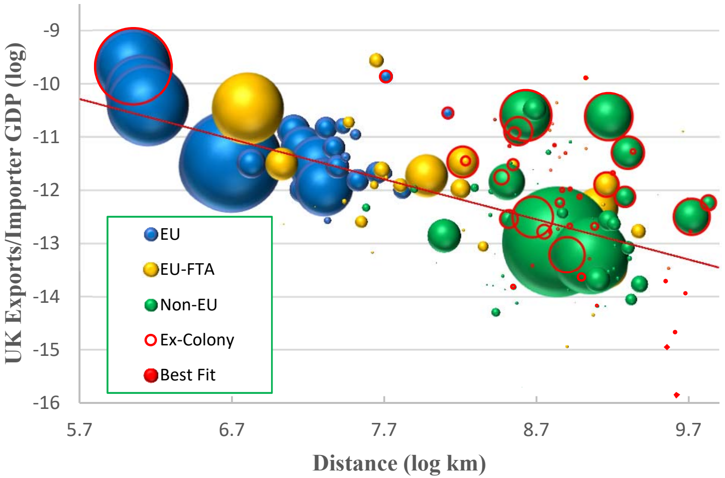
Gravity Weighted by Exports, UK, 2017



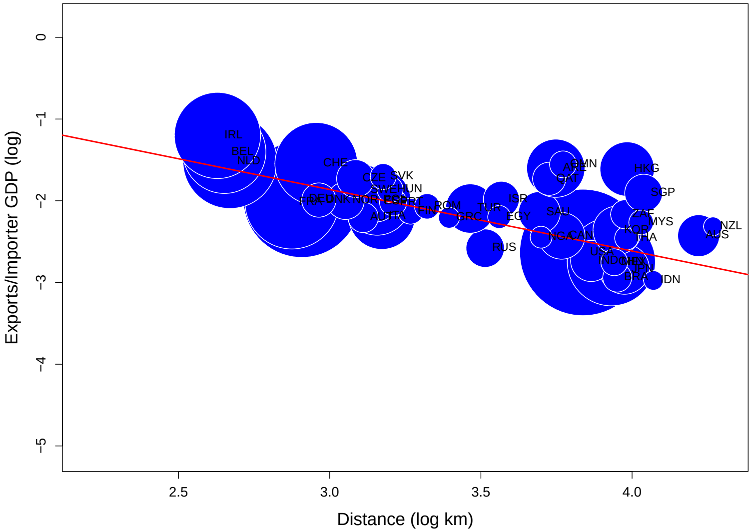
Trade Agreements, UK, 2017



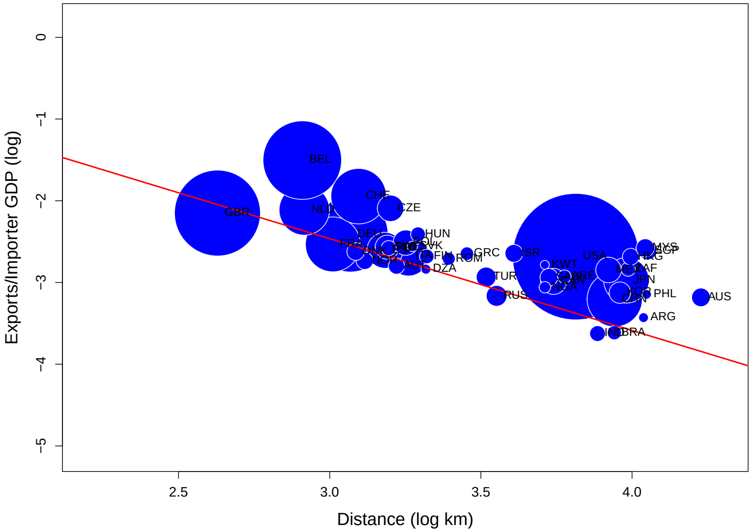
Trade Agreements and ex-Colonies, UK, 2017



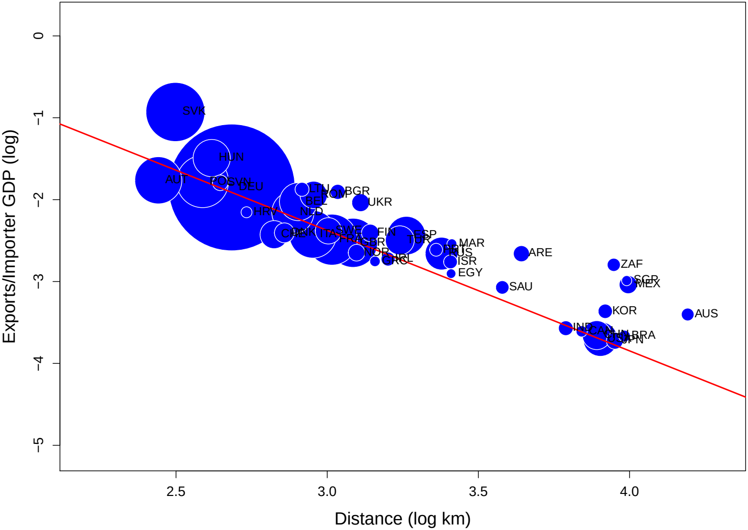
Gravity, UK, 2017: -0.752 (0.098)



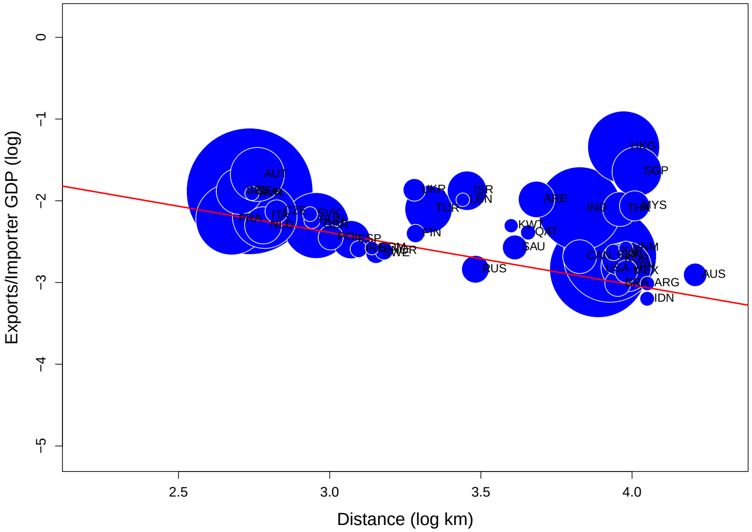
Gravity, Ireland, 2017: -1.123 (0.150)



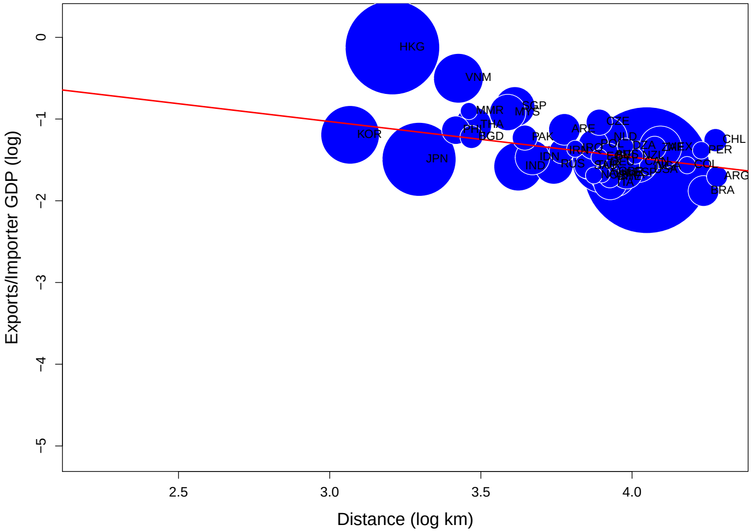
Gravity, Czech Republic, 2017: -1.471 (0.109)



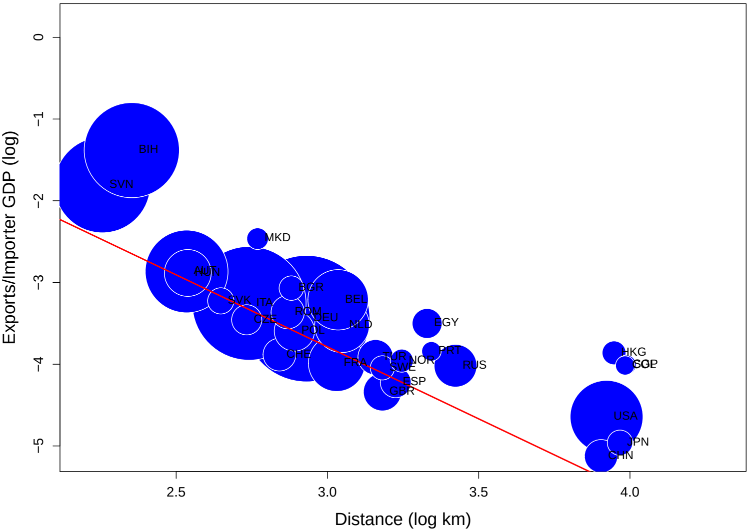
Gravity, Switzerland, 2017: -0.642 (0.106)



Gravity, China, 2017: -0.437 (0.145)



Gravity, Croatia, 2017: $-1.762\ (0.178)$



Outline

1. Gravity as Fact
2. **Gravity as Theory**
   - Structural Gravity
   - Comparative Statics for Structural Gravity
   - An Application: Brexit
3. Gravity Anomalies
4. Subconvex Gravity
5. Conclusion

Gravity as Theory

"[I] have explained the phenomena of the heavens and of our sea by the power of gravity, but have not yet assigned the cause of this power."

– Isaac Newton (1713)

"The intent of this paper is to provide a theoretical explanation for the gravity equation applied to commodities."

– Jim Anderson (1979)

Foundations of the Gravity Model

- A variety of different supply sides, all with CES preferences
- The gravity equation has been shown to be consistent with:
    - Armington (1969) model of pure exchange
        - Anderson (1979), Anderson and van Wincoop (2003)
    - Models of monopolistic competition such as Krugman (1980)
        - Bergstrand (1985) and Helpman (1987)
    - Heterogeneous-firms model of Melitz (2003)
        - Chaney (2008)
    - Multi-country Ricardian model
        - Eaton and Kortum (2002)
    - Synthesis: Arkolakis, Costinot, and Rodríguez-Clare (2012)
- All yield the same “structural gravity” model
    - Here: We focus on the simplest Armington-based version

Start with CES Demands

- n countries, each endowed with a unique good
- Common CES preferences: Each country consumes all goods:

$$x_{jk} = \beta_j \left(\frac{p_{jk}}{P_k}\right)^{-\sigma} \frac{E_k}{P_k} \quad \Rightarrow \quad V_{jk} = \beta_j \left(\frac{p_{jk}}{P_k}\right)^{1-\sigma} E_k$$

  - $V_{jk} = p_{jk} x_{jk}$: Value of exports from j to k
  - β_j: Taste parameter for country j good
  - p_{jk}: Delivered price of j's export in k
    - $p_{jk} = p_j t_{jk}$: Equals home price times an "iceberg" trade cost
  - P_k: Importer price index:

$$P_k = \left(\sum_h \beta_h p_{hk}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$$

  - σ: Elasticity of substitution
  - E_k: Country k's expenditure on all goods

From CES Demands to Structural Gravity

- Total sales by country j sum to GDP in equilibrium:

$$\sum_k V_{jk} = Y_j$$

Forward

- Substitute into this from CES demands:

$$Y_j = \sum_k V_{jk} = (\beta_j p_j)^{1-\sigma} \sum_k \left(\frac{t_{jk}}{P_k}\right)^{1-\sigma} E_k$$

- Use this to eliminate $(\beta_j p_j)^{1-\sigma}$ from V_{jk} and P_k

Structural Gravity

- Structural gravity:

[Anderson (1979), Anderson and van Wincoop (2003)]

$$V_{jk} = \underbrace{\left(\frac{t_{jk}}{\Pi_j P_k}\right)^{1-\sigma}}_{(1)} \underbrace{\frac{Y_j E_k}{Y_W}}_{(2)}$$

(2): Frictionless trade: Y_W is world income

(1): Trade costs relative to outward and inward "multilateral resistance":

$$(\Pi_j)^{1-\sigma} = \sum_h \left(\frac{t_{jh}}{P_h}\right)^{1-\sigma} \frac{E_h}{Y_W} \qquad (P_k)^{1-\sigma} = \sum_h \left(\frac{t_{hk}}{\Pi_h}\right)^{1-\sigma} \frac{Y_h}{Y_W}$$

- Π_j: Index of outward trade costs
- P_k: In equilibrium, price index is also an index of inward trade costs
- Dual to one another

Sect3 Sect4

Uses of Structural Gravity

- Estimation
  - Usually in log-linear form with importer and exporter fixed effects:

$$\log V_{jk} = F_j + F_k + \beta \log t_{jk} + u_{jk}, \qquad t_{jk} = \delta_{jk} \exp(\gamma' D_{jk})$$

▸ Compare

- Simulation
  - Policy analysis, e.g. Brexit
- Theoretical Analysis
  - Not possible in levels
  - What about comparative statics for local changes?

Comparative Statics for Structural Gravity

- Allen, Arkolakis, and Takahashi (2019)
  - Dekle, Eaton and Kortum (2008)
- Baqaee and Farhi (2017)
- Jones (1965)
  - Diewert and Woodland (1977), Jones and Scheinkman (1977)

The Structure of Simple Structural Gravity Models

- Comparative Statics:
  - Define GDP and expenditure shares:

$$\lambda_{jk} = \frac{V_{jk}}{Y_j} \qquad \theta_{jk} = \frac{V_{jk}}{E_k}$$

Back

    - Country j small: $\lambda_{kj} \approx 0$ and $\theta_{jk} \approx 0, \ \forall\ k \neq j$
  - Express changes in terms of these:

$$[\hat{x} \equiv d \log x]$$

$$Y_j = \sum_k V_{jk} \quad \Rightarrow \quad \hat{Y}_j = \sum_k \lambda_{jk} \hat{V}_{jk} \quad \Rightarrow \quad 0 = \sum_k \lambda_{jk} \left(\hat{\tau}_{jk} + \hat{x}_{jk} \right)$$

$$P_k = \left(\sum_j p_{jk}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad \Rightarrow \quad \hat{P}_k = \sum_j \theta_{jk} \hat{p}_{jk}$$

Gravity at the Margin

- Demands at the margin:

$$\hat{x}_{jk} = -\sigma \hat{p}_{jk} + (\sigma - 1)\hat{P}_k + \hat{E}_k$$

  - Own and cross-price derivatives:

$$\frac{\partial \log x_{jk}}{\partial \log p_{jk}} = -\left(\sigma(1-\theta_{jk}) + \theta_{jk}\right) \qquad \left.\frac{\partial \log x_{jk}}{\partial \log p_{hk}}\right|_{h \neq j} = (\sigma - 1)\theta_{hk}$$

    - Gross substitutes: $-\frac{\partial \log x_{jk}}{\partial \log p_{jk}} > \frac{\partial \log x_{jk}}{\partial \log p_{hk}} > 0$

- Add:
  - Trade costs: $p_{jk} = p_j t_{jk} \quad \Rightarrow \quad \hat{p}_{jk} = \hat{p}_j + \hat{t}_{jk}$
  - Balanced trade: $E_j = \kappa_j Y_j \quad \Rightarrow \quad \hat{E}_j = \hat{Y}_j$
  - Supply side: $\left\{ \begin{array}{rcl} Y_j &=& p_j Q_j \\ w_j &=& p_j \end{array} \right\} \quad \Rightarrow \quad \hat{Y}_j = \hat{w}_j = \hat{p}_j$

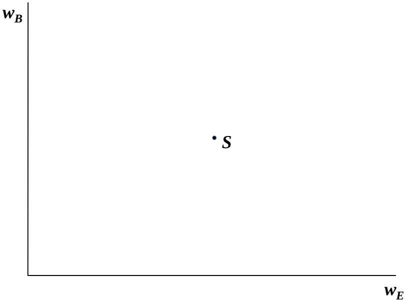
An Application: Brexit

- Specialize to 3 countries: A, B, and E
  - A and E large
  - Take country A's good as numéraire, so $p_A = 1$
  - Equilibrium: Market-clearing conditions for outputs of B and E ...
  - ... determine equilibrium wages: $w_B = p_B$ and $w_E = p_E$

Goods-Market Equilibrium

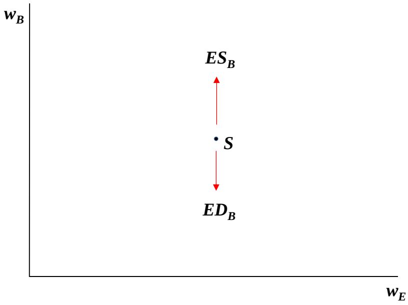
- Illustrate equilibrium in $\{p_E, p_B\}$, i.e., $\{w_E, w_B\}$ space

Goods-Market Equilibrium



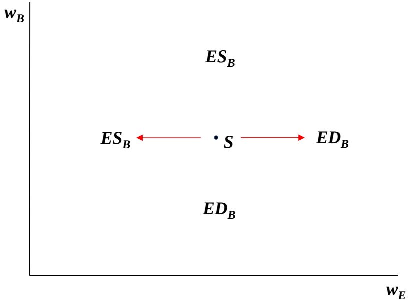
- Initial equilibrium at S.
- Goods-market-equilibrium locus for good B?

Goods-Market Equilibrium



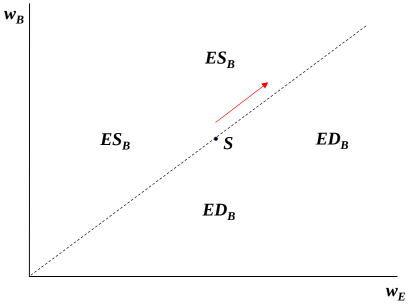
- Goods-market-equilibrium locus for good B:
  - Higher w_B, i.e. p_B, leads to excess supply, lower to excess demand

Goods-Market Equilibrium



- Goods-market-equilibrium locus for good B:
  - Higher w_B, i.e. p_B, leads to excess supply, lower to excess demand
  - Conversely for w_E, though effect is weaker
    - Gross substitutes in each market, and so in all

Goods-Market Equilibrium



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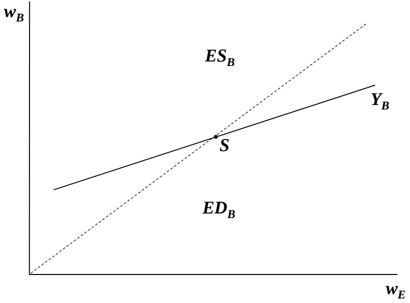
  - Uniformly higher w_B and w_E leads to excess supply

Goods-Market Equilibrium



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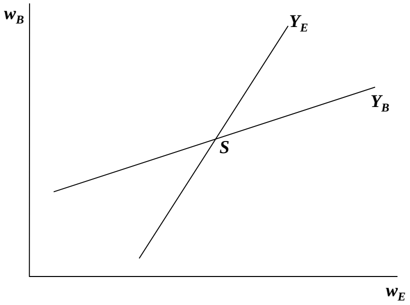
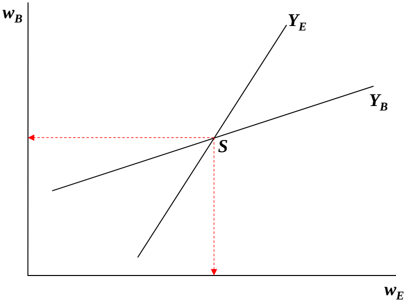
  - Conversely for w_E, though effect is weaker
    - Gross substitutes in each market, and so in all
  - Uniformly higher w_B and w_E leads to excess supply
  - So market-clearing locus is upward-sloping as shown

Goods-Market Equilibrium



- Similarly for good E
  - Close to vertical if B is small

Goods-Market Equilibrium



- Intersection of the two determines equilibrium wages w_B and w_E

Trade Cost Scenarios

- Decompose trade costs: [Maggi, Mrázová, and Neary (2018)]

$$t_{jk} = \delta_{jk}\tau_{jk} \quad \begin{cases} \delta_{jk}: & \text{“natural”} \\ \tau_{jk}: & \text{policy-induced} \end{cases}$$

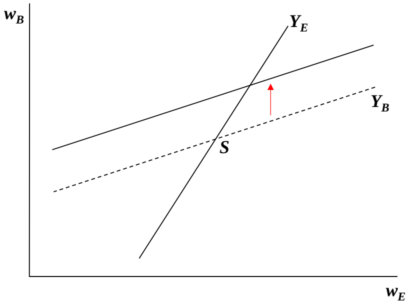
- Possible scenarios:

Scenario	δ_{BE}	τ_{BE}	δ_{BA}	τ_{BA}
Status quo	low	low	high	high
“Cake and Eat”	low	low	high	low
“Global Britain”	low	high	high	low

(1) All assumed to be bilaterally symmetric.

(2) Revenue from policy costs ignored.

"Cake and Eat"

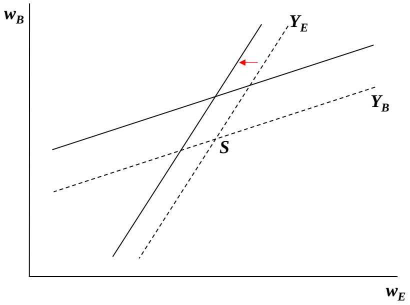


- Lower τ_{BA}: ambiguous effect on demand for Y_B; assume for now it raises it

$$\frac{\partial \log X_B}{\partial \log \tau_{BA}} = -(\sigma - 1)(\underbrace{\lambda_{BA}(1-\theta_{BA})}_{(1)>0} \underbrace{-\lambda_{BB}\theta_{AB}}_{(2)<0})$$

1. Lower trade cost $B \rightarrow A$: raises export demand for good B ▸ Details
2. Lower trade cost $A \rightarrow B$: lowers home demand for good B ▸ (2)

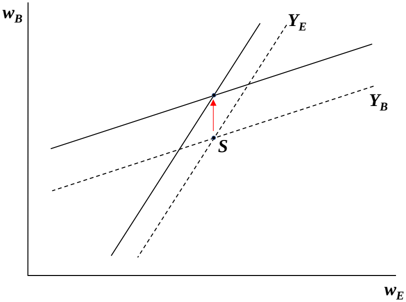
"Cake and Eat"



- Lower τ_{BA} also lowers demand for Y_E, though not by much if B is small

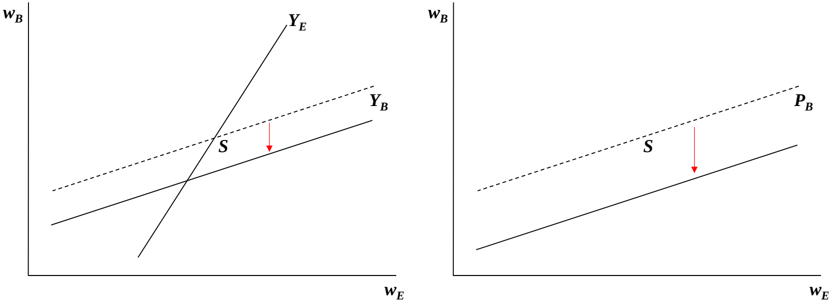
$$\frac{\partial \log X_E}{\partial \log \tau_{BA}} = (\sigma - 1)(\lambda_{EA} \underbrace{\theta_{BA}} + \underbrace{\lambda_{EB}} \theta_{AB})$$

"Cake and Eat"



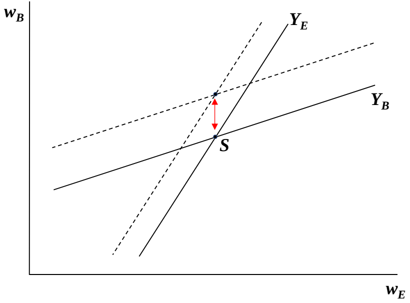
- Net effect: Rise in w_B, ambiguous change in w_E
  - $w_B \uparrow \;\Leftrightarrow\; \hat{w}_B > \hat{w}_A$: Because A is bigger

"Cake and Eat": Wages in B May Fall



- What if lower τ_{BA} reduces demand for Y_B? Recall
  - This is because θ_{AB} is large enough that home demand for B falls
  - But in this case the price level also falls a lot
  - When B is small these effects exactly cancel, so effect of higher exports dominates: real wage in B definitely rises
  - This result holds for any number of countries

"Global Britain": Symmetric Benchmark



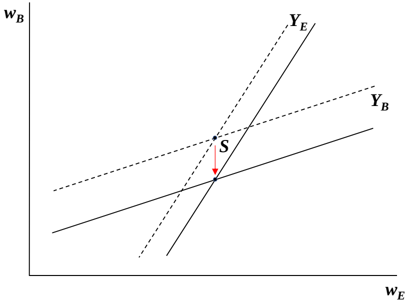
- Complete symmetry between A and E: No net effect
  - $\tau_{BE} \uparrow$ exactly offsets the effect of $\tau_{BA} \downarrow$

"Global Britain": Departures from Symmetry

- Depth of integration
  - Single market is a deeper trade agreement: $\tau_{BE}\Big|_S < \tau_{BA}\Big|_{GB}$
- Size
  - What matters is not absolute size, but size in initial UK trade
  - EU27 accounts for 40% of 2017 UK trade; but countries with EU trade agreements add another 15%
- Asymmetries between increases in low policy costs and decreases in high ones
  - This matters for discrete changes
  - Cost of 10%-point increase in τ_{BE} is greater than the gain from a 10%-point decrease in τ_{BA}
- Distance a fixed cost

$$t_{jk} = \delta_{jk} + \tau_{jk} \quad \Rightarrow \quad \hat{t}_{jk} = (1 - \omega_{jk})\hat{\tau}_{jk}, \quad \omega_{jk} \equiv \frac{\delta_{jk}}{t_{jk}}$$

"Global Britain": Reality Bites



- Net effect: Higher trade costs with E dominate
  - More than offset the (only slightly) lower trade costs with A

Outline

1. Gravity as Fact
2. Gravity as Theory
3. **Gravity Anomalies**
   - Gravity Anomalies: Markups and Pass-Through
   - Gravity Anomalies: Bilateral Trade Balances
4. Subconvex Gravity
5. Conclusion

Gravity Anomalies

- Counter-factual implications of CES preferences:
  1. Firm-level markups and pass-through
     - CES demands imply constant markups and 100% pass-through
     - But: Mounting firm-level empirical evidence to the contrary ▸ Data
     - Empirics: De Loecker et al.(2016); theory: Mrázová and Neary (2017)
  2. Elasticities of import demand across markets
     - Evidence that they vary by market size and distance: Novy (2013)
  3. Bilateral trade balances
     - CES gravity imposes very strong counter-factual restrictions ▸ Details

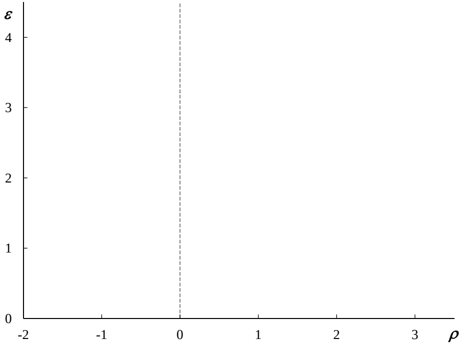
▸ Skip

Firm-Level Evidence Against CES

- Inverse demand function:

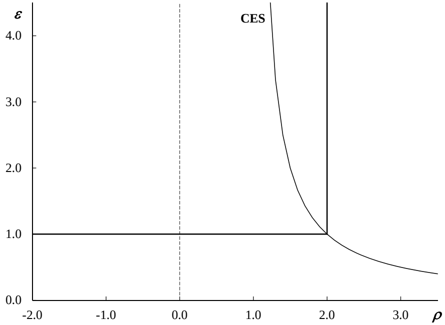
$$p = p(x) \qquad p' < 0$$

- Two key demand parameters:
  1. Slope/Elasticity:
  $\varepsilon(x) \equiv -\frac{p(x)}{xp'(x)} > 0$
  2. Curvature/Convexity:
  $\rho(x) \equiv -\frac{xp''(x)}{p'(x)}$



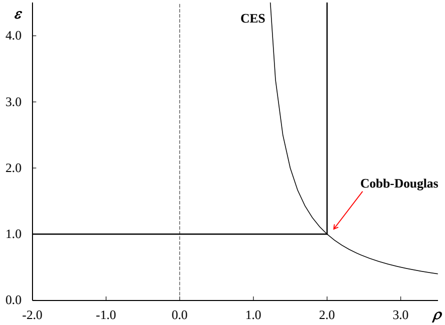
CES Demands

- In general, both ε and ρ vary with sales
- Exception: CES/iso-elastic case:
  - $p = \beta x^{-1/\sigma}$
  - $\Rightarrow \quad \varepsilon = \sigma, \;\; \rho = \frac{\sigma+1}{\sigma} > 1$
  - $\Rightarrow \quad \varepsilon = \frac{1}{\rho-1}$



CES Demands

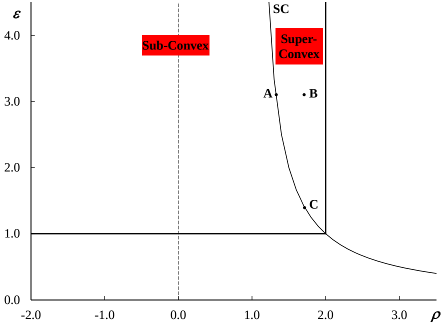
- In general, both ε and ρ vary with sales
- Exception: CES/iso-elastic case:
  - $p = \beta x^{-1/\sigma}$
  - $\Rightarrow \quad \varepsilon = \sigma, \ \ \rho = \frac{\sigma+1}{\sigma} > 1$
  - $\Rightarrow \quad \varepsilon = \frac{1}{\rho - 1}$
- Cobb-Douglas: $\varepsilon = 1, \rho = 2$



Sub- and Superconvexity

$p(x)$ is subconvex at x^0 IFF:

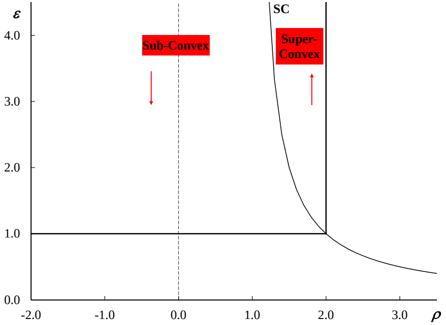
- $\log p(x)$ is concave in $\log x$
- $p(x)$ is less convex than a CES demand function with the same elasticity: $\rho < \frac{\varepsilon+1}{\varepsilon}$



Sub- and Superconvexity

$p(x)$ is subconvex at x^0 IFF:

- $\log p(x)$ is concave in $\log x$
- $p(x)$ is less convex than a CES demand function with the same elasticity: $\rho < \frac{\varepsilon+1}{\varepsilon}$
- ε is decreasing in sales:
  - $\varepsilon_x = \frac{\varepsilon}{x}\left(\rho - \frac{\varepsilon+1}{\varepsilon}\right)$

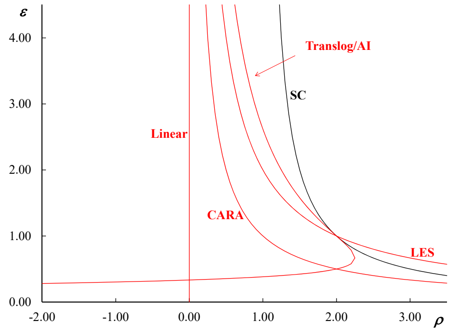


- Subconvexity confirmed empirically, and theoretically plausible:
  - Introspection: "Marshall's 2nd Law of Demand"
  - Dixit and Stiglitz (1977), Krugman (1979), etc.

From Demand Functions to Demand Manifolds

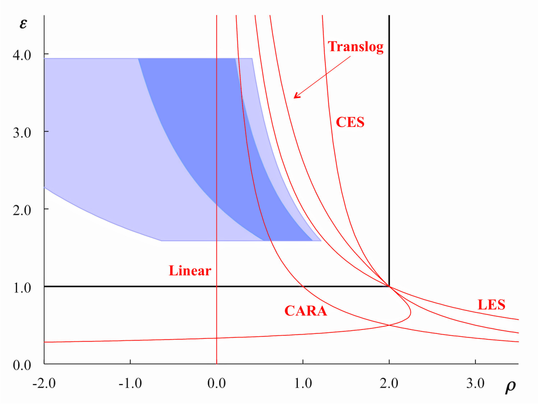
- Represent demand functions in $\{\varepsilon, \rho\}$ space by their *Demand Manifold*
  - *Definition*: A curve in $\{\varepsilon, \rho\}$ space corresponding to the demand function $p(x)$
  - *Existence*: A smooth manifold corresponds to every demand function
    - Except for CES: Manifold is a point
  - *Invariance*: $\varepsilon(x, \phi)$ and $\rho(x, \phi) \quad \Rightarrow \quad \rho(\varepsilon)$?
    - Necessary and sufficient condition in Mrázová-Neary (2017)
    - Holds for most widely-used demand functions

Manifolds for Some Common Demand Functions



- All manifold-invariant

Evidence Rejects CES



- Mrázová and Neary (2017) show that ε and ρ can be inferred from estimates of pass-through and markups (as in de Loecker et al. (2016)) Recall
- CES lies outside the implied confidence regions

Gravity Anomalies 3: Bilateral Trade Balances

- Structural gravity predicts bilateral trade flows V_{jk}
- So it also predicts their *ratios*: bilateral trade balances V_{jk}/V_{kj}
  - Precedent for this: *Products* of trade flows widely used to infer trade costs and elasticity of trade ▸ Details
    - Head and Ries (2001), Jacks, Meissner, and Novy (2008), Caliendo and Parro (2015)
  - Precursors:
    - Davis and Weinstein (2002): "Mystery of the Excess Trade (Balances)"
    - Badinger and Fichet de Clairfontaine (2018), Cunat and Zymek (2018), Felbermayr and Yotov (2019)

Bilateral Trade Balances: The Simplest Case

- Assume (for now) symmetric bilateral trade costs and balanced trade:
  - *Divide* bilateral trades:

▸ Recall Gravity

$$\frac{V_{jk}}{V_{kj}} = \left(\frac{\Pi_j}{P_j}\right)^{\sigma-1} \Big/ \left(\frac{\Pi_k}{P_k}\right)^{\sigma-1}$$

  - But: With symmetric bilateral trade costs, $P_j = \lambda \Pi_j$
    - Anderson and van Wincoop (2003)
    - They go further and set $\lambda = 1$: "an implicit normalization"
    - a.k.a. a choice of numéraire
    - Not advisable if another numéraire has already been chosen!

[Baldwin and Taglioni (2007)]

  - So: All trade balances are zero!

Bilateral Trade Balances: Robustness

- In logs:

$$v_{jk} - v_{kj} = \rho_j - \rho_k$$

- This continues to hold with unbalanced trade:

$$\Rightarrow \quad \rho_j = \log\left(\frac{\Pi_j}{P_j}\right)^{\sigma-1} + \log\left(\frac{I_j}{E_j}\right)$$

- And with *quasi*-symmetric bilateral trade costs:

$$t_{jk} = t_j^X \bar{t}_{jk} t_k^M, \quad \bar{t}_{jk} = \bar{t}_{kj}$$

  - Eaton and Kortum (2002), Allen and Arkolakis (2016)
  - Allows for home bias and border effects: Head and Ries (2001)

$$\Rightarrow \quad \rho_j = \log\left(\frac{\Pi_j}{P_j}\right)^{\sigma-1} + \log\left(\frac{I_j}{E_j}\right) + \log\left(\frac{t_j^X}{t_j^M}\right)^{1-\sigma}$$

  - i.e., relative multilateral resistance, adjusted for both overall trade surplus and border effects

Bilateral Trade Balances: Recap

- So:

$$v_{jk} - v_{kj} = \rho_j - \rho_k$$

  - $\frac{1}{2}n(n-1)$ terms, $v_{jk} - v_{kj}$, determined by n relative multilateral resistance terms ρ_j

- Conclusion:
  - With unbalanced trade and quasi-symmetric trade costs, the bilateral trade balances between any country j and all other countries are independent of j, except for a factor of proportionality.

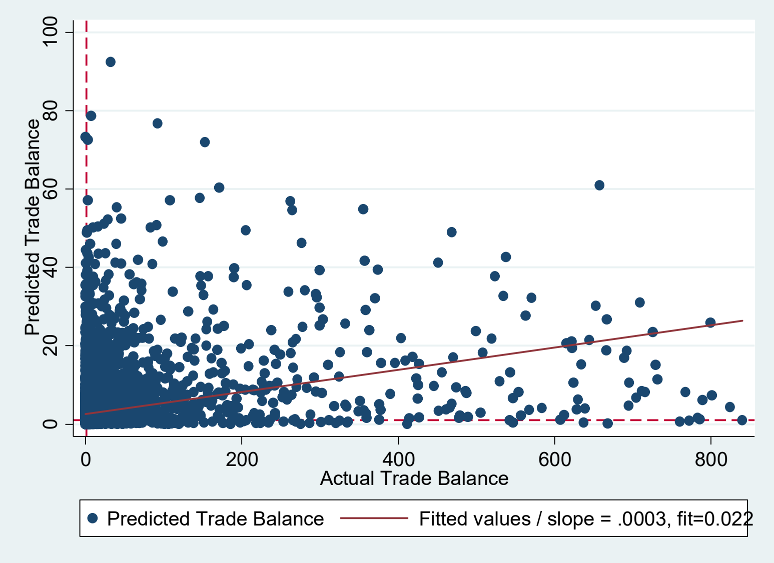
Implications

- Yet another elegant implication of CES?
- Or: Yet another implausible prediction of CES?!
- To test it:

$$\log V_{jk} - \log V_{kj} = \sum_{h=1}^{n-1} \beta_h D_h(j,k), \quad D_h(j,k) = \begin{cases} 1 & \text{when } h = j \\ -1 & \text{when } h = k \\ 0 & \text{when } h \neq j, k \end{cases}$$

  - Same $n = 182$ countries, 2017
  - All n $D_h(j,k)$ are perfectly collinear, so drop D_{US}
  - Total number of observations: 182.181/2= 16,471
  - Country pairs with any zero dropped, leaving 9,314
- Results:
  - $R^2 = 0.340$
  - Hypothesis $\{H_0 : \ \beta_h = 0\}$ is rejected at 5% for 70% of the β_h
  - But: A very poor fit for the trade balances in levels

Predicted versus Actual Trade Balances, 2017



Outline

1 Gravity as Fact

2 Gravity as Theory

3 Gravity Anomalies

4 **Subconvex Gravity**

5 Conclusion

Beyond Gravity Anomalies: Subconvex Gravity

- Assume additively separable demands:

$$u'(x_{jk}) = \lambda_k p_{jk} \quad \Rightarrow \quad x_{jk} = f\left(\lambda_k p_j t_{jk}\right)$$

$$\rightarrow \quad \hat{V}_{jk} = -(\sigma_{jk} - 1)\hat{p}_j - \sigma_{jk}\hat{\lambda}_k - \left(\sigma_{jk} - 1\right)\hat{t}_{jk}$$

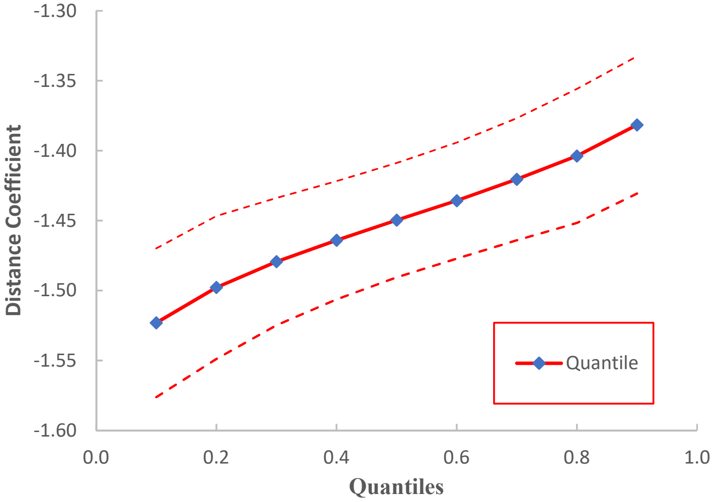
- Subconvexity: $\sigma_{jk} \equiv \sigma\left(x_{jk}\right)$, decreasing in x_{jk}
- To estimate this, we use quantile regression:
  - Order data by V_{jk}
  - Estimate for each quantile q:

Recall CES

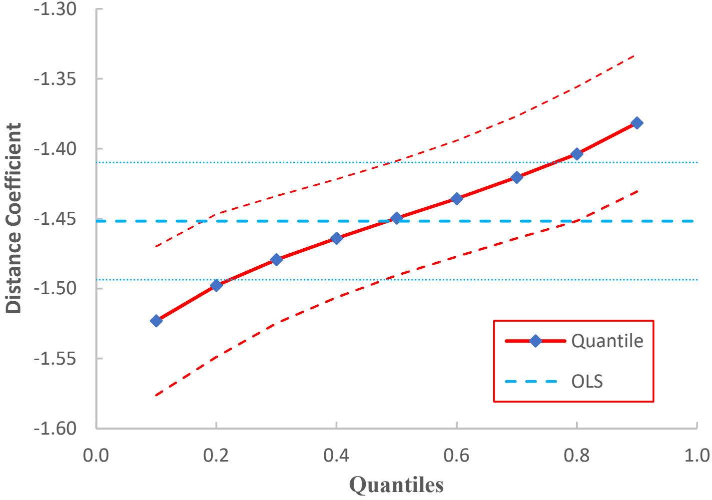
$$\log V_{q,jk} = F_{q,j} + F_{q,k} + \beta_q \log t_{jk} + u_{q,jk}$$

  - Estimation and bootstrapped confidence intervals:
    - Baltagi and Egger (2016), Machado and Santos Silva (2019)

Quantile Regression: Estimated Distance Coefficient



Quantile Regression Results: Compared to OLS



Quantile Regression Results: Tests

Significance Tests for Differences Between
Quantile and OLS Estimates of Distance Coefficient

	β_{OLS}	β_{Q10}	β_{Q20}	β_{Q30}	β_{Q40}	β_{Q50}	β_{Q60}	β_{Q70}	β_{Q80}	β_{Q90}
β_{Q10}	*	0								
β_{Q20}	n.s.	n.s.	0							
β_{Q30}	n.s.	n.s.	n.s.	0						
β_{Q40}	n.s.	*	n.s.	n.s.	0					
β_{Q50}	n.s.	*	n.s.	n.s.	n.s.	0				
β_{Q60}	n.s.	*	*	n.s.	n.s.	n.s.	0			
β_{Q70}	n.s.	*	*	*	n.s.	n.s.	n.s.	0		
β_{Q80}	n.s.	*	*	*	*	n.s.	n.s.	n.s.	0	
β_{Q90}	*	*	*	*	*	*	*	n.s.	n.s.	0

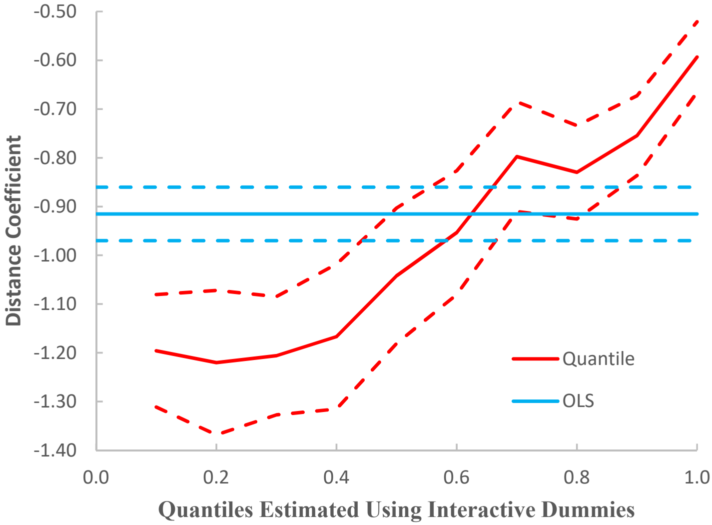
* Significantly different at 5% level
n.s. Not significant

Robustness: Interactive Dummies

- Robustness check in the spirit of Novy (2013):
  - Quantile dummies for intercept and interacted with all OLS coefficients
  - Quantile dummies computed on the *predicted* value of trade
    - i.e., $\log \widehat{V_{jk}} = F_j + F_k + \hat{\beta} \log t_{jk}$
    - Estimated distance coefficient is not the same as in the QR case as different fixed effects are used: $F_j + F_k + F_q$ instead of $F_j + F_k$

$$\log V_{jk} = F_j + F_k + F_q + \beta_q F_q \log t_{jk} + u_{jk}$$

Robustness: Interactive Dummies Regression



Subconvex Gravity: Evidence and Implications

- Persuasive Evidence for Subconvexity
  - Distance coefficient significantly decreasing (in absolute value) in trade
  - Replication needed ...
  - Chernozhukov, Fernandez-Val, and Weidner (2018) find the opposite with 1986 data
- Implications for the Trade Balances Puzzle?
  - Bilateral balances now depend on distance
  - Provisional evidence confirming this
- Implications for Brexit?
  - With subconvexity, elasticities are higher in smaller markets
  - Implications for estimated effects of Brexit unlikely to be major

Outline

1. Gravity as Fact
2. Gravity as Theory
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5. **Conclusion**

Conclusion

- Gravity as Fact
  - Overwhelming evidence that trade tends to fall with distance
- Gravity as Theory
  - A simple general equilibrium system
  - New analytic tools for understanding it
- Gravity Anomalies
  - Constant Elasticity of Trade not the whole story
- Subconvex gravity a promising direction
  - Unlikely to change the Three Iron Laws of the Economics of Brexit

Thanks and Acknowledgements*

Thank you for listening. Comments welcome!

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Details: Goods-Market Equilibrium

- Equilibrium in market for Y_B:

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$$\hat{X}_B = \varepsilon_{BB}\hat{p}_B + \varepsilon_{BE}\hat{p}_E + \varepsilon_{Bt_E}\hat{t}_{BE} + \varepsilon_{Bt_A}\hat{t}_{BA} = 0$$

  - where the elasticities of excess demand for Y_B are:

$$\begin{aligned}
\varepsilon_{BB}: &\ -(\sigma-1)\lambda_{BB}(1-\theta_{BB}) - \lambda_{BE}\{\sigma(1-\theta_{BE})+\theta_{BE}\} - \lambda_{BA}\{\sigma(1-\theta_{BA})+\theta_{BA}\} \\
\varepsilon_{BE}: &\ (\sigma-1)\lambda_{BB}\theta_{EB} + \lambda_{BE}\{(\sigma-1)\theta_{EE}+1\} + (\sigma-1)\lambda_{BA}\theta_{EA} \\
\varepsilon_{Bt_E}: &\ -(\sigma-1)\{\lambda_{BE}(1-\theta_{BE}) - \lambda_{BB}\theta_{EB}\} \\
\varepsilon_{Bt_A}: &\ -(\sigma-1)\{\lambda_{BA}(1-\theta_{BA}) - \lambda_{BB}\theta_{AB}\}
\end{aligned}$$

- Similarly in the market for Y_E:

$$\hat{X}_E = \varepsilon_{EB}\hat{p}_B + \varepsilon_{EE}\hat{p}_E + \varepsilon_{Et_E}\hat{t}_{BE} = 0$$

$$\begin{aligned}
\varepsilon_{EB}: &\ (\sigma-1)\lambda_{BB}\theta_{EB} + \lambda_{BE}\{(\sigma-1)\theta_{EE}+1\} + (\sigma-1)\lambda_{BA}\theta_{EA} \\
\varepsilon_{EE}: &\ -(\sigma-1)\lambda_{BB}(1-\theta_{BB}) - \lambda_{BE}\{\sigma(1-\theta_{BE})+\theta_{BE}\} - \lambda_{BA}\{\sigma(1-\theta_{BA})+\theta_{BA}\} \\
\varepsilon_{Et_E}: &\ -(\sigma-1)\{\lambda_{BE}(1-\theta_{BE}) - \lambda_{BB}\theta_{EB}\} \\
\varepsilon_{Et_A}: &\ 0
\end{aligned}$$

Gravity Anomalies: Micro Evidence

Back1 Back2

- Markups and pass-through in general:

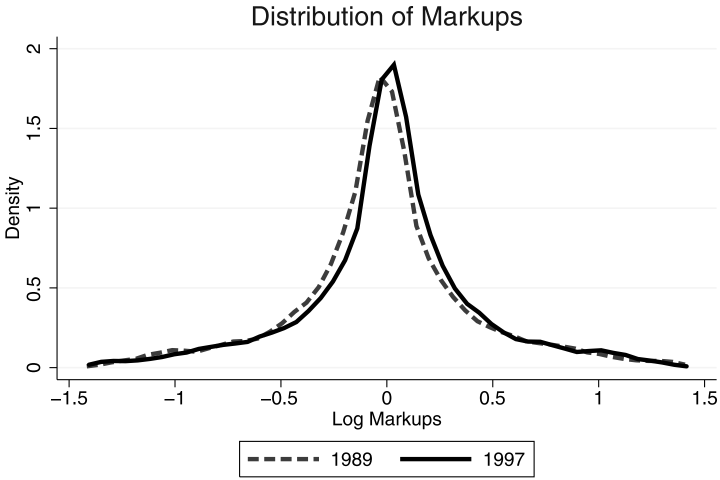
$$\frac{p-c}{c} = \frac{1}{\varepsilon - 1} \quad \text{and} \quad \frac{d\log p}{d\log c} = \frac{\varepsilon - 1}{\varepsilon}\frac{1}{2-\rho}$$

- CES demands imply constant markups and 100% pass-through:

$$\frac{p-c}{c} = \frac{1}{\sigma - 1} \quad \text{and} \quad \frac{d\log p}{d\log c} = 1$$

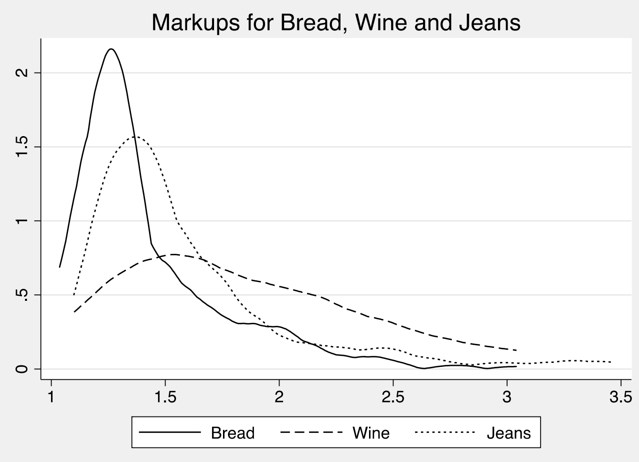
- But: Mounting empirical evidence to the contrary
- Mark-ups differ a lot across firms, even in narrowly-defined industries.

Empirical Evidence on Markups I



From: de Loecker, Goldberg, Khandelwal and Pavcnik (2016)

Empirical Evidence on Markups II



From: Lamorgese, Linarello and Warzynski (2014)

Back to text

Gravity Anomalies: Cross-Market Heterogeneity

Back to text

- CES-based models predict the same elasticity of import demand in all markets.
    - Macro elasticity, not micro elasticity facing firms
- By contrast, Novy (2013) finds that elasticities are systematically lower in larger and closer markets.

An Implication of Constant-Trade-Elasticity Gravity

- Inferring trade costs from trade volumes:
  [Head and Ries (2001), Jacks, Meissner, and Novy (2008)]

▸ Back to text

  - Multiply bilateral trades and divide by domestic trades:

$$\frac{V_{jk}V_{kj}}{V_{jj}V_{kk}} = \left(\frac{t_{jk}t_{kj}}{t_{jj}t_{kk}}\right)^{1-\sigma}$$

  - Invert to solve for trade costs in terms of observables:

$$\left(\frac{t_{jk}t_{kj}}{t_{jj}t_{kk}}\right)^{\frac{1}{2}} = \left(\frac{V_{jk}V_{kj}}{V_{jj}V_{kk}}\right)^{\frac{1}{2(1-\sigma)}}$$

  - Even simpler with symmetric bilateral and zero internal trade costs:

$$t_{jk} = \left(\frac{V_{jk}V_{kj}}{V_{jj}V_{kk}}\right)^{\frac{1}{2(1-\sigma)}}$$

References I

Alabrese, E., S. O. Becker, T. Fetzer, and D. Novy (2019): "Who Voted for Brexit? Individual and Regional Data Combined," *European Journal of Political Economy*, 56, 132–150.

Allen, T., and C. Arkolakis (2016): "Elements of Advanced International Trade," `http://www.econ.yale.edu/~ka265/teaching.htm`.

Allen, T., C. Arkolakis, and Y. Takahashi (2019): "Universal Gravity," *Journal of Political Economy*, forthcoming.

Anderson, J. E. (1979): "A Theoretical Foundation for the Gravity Equation," *American Economic Review*, 69(1), 106–116.

Anderson, J. E., and E. van Wincoop (2003): "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, 93(1), 170–192.

Arkolakis, C., A. Costinot, and A. Rodríguez-Clare (2012): "New Trade Models, Same Old Gains?," *American Economic Review*, 102(1), 94–130.

Armington, P. S. (1969): "A Theory of Demand for Products Distinguished by Place of Production," *International Monetary Fund Staff Papers*, 16(1), 159–178.

References II

Badinger, H., and A. Fichet de Clairfontaine (2018): "Trade Balance Dynamics and Exchange Rates: In Search of the J-Curve Using a Structural Gravity Approach," Working Paper No. 256, Department of Economics, WU Vienna.

Baltagi, B. H., and P. Egger (2016): "Estimation of Structural Gravity Quantile Regression Models," *Empirical Economics*, 50(50), 5–15.

Baqaee, D. R., and E. Farhi (2017): "Productivity and Misallocation in General Equilibrium," CEPR Discussion Paper No. 12447.

Bergstrand, J. H. (1985): "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence," *Review of Economics and Statistics*, 67(3), 474–481.

Brakman, S., H. Garretsen, and T. Kohl (2018): "Consequences of Brexit and options for a Global Britain," *Papers in Regional Science*, 97(1), 55–72.

Cairncross, F. (1997): *The Death of Distance*. London: Texere Publishing.

Caliendo, L., and F. Parro (2015): "Estimates of the Trade and Welfare Effects of NAFTA," *Review of Economic Studies*, 82(1), 1–44.

Carrère, C., M. Mrázová, and J. P. Neary (2019): "Subconvex Gravity," in preparation.

References III

Chaney, T. (2008): "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, 98(4), 1707–1721.

Chernozhukov, V., I. Fernandez-Val, and M. Weidner (2018): "Network and Panel Quantile Effects via Distribution Regression," CEMMAP Working Paper CWP21/18, UCL.

Cowgill, B., and C. Dorobantu (2012): "Gravity and Borders in Online Commerce: Results from Google," mimeo., Department of Economics, University of Oxford.

Cunat, A., and R. Zymek (2018): "Bilateral Trade Imbalances," mimeo., University of Vienna.

Davies, R. B., and Z. Studnicka (2018): "The Heterogeneous Impact of Brexit: Early Indications from the FTSE," *European Economic Review*, 110, 1–17.

Davis, D. R., and D. E. Weinstein (2002): "The Mystery of the Excess Trade (Balances)," *American Economic Review*, 92(2), 170–174.

De Loecker, J., P. K. Goldberg, A. K. Khandelwal, and N. Pavcnik (2016): "Prices, Markups and Trade Reform," *Econometrica*, 84(2), 445–510.

References IV

Dhingra, S., H. Huang, G. Ottaviano, J. Paulo Pessoa, T. Sampson, and J. Van Reenen (2017): "The Costs and Benefits of Leaving the EU: Trade Effects," *Economic Policy*, 32(92), 651–705.

Diewert, W. E., and A. D. Woodland (1977): "Frank Knight's Theorem in Linear Programming Revisited," *Econometrica*, 45(2), 375–398.

Dixit, A. K., and J. E. Stiglitz (1977): "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 67(3), 297–308.

Eaton, J., and S. Kortum (2002): "Technology, Geography, and Trade," *Econometrica*, 70(5), 1741–1779.

Friedman, T. (2005): *The World is Flat*. New York: Farrar, Straus and Giroux.

Gould, S. J. (1981): "Evolution as Fact and Theory," *Discover*, 2, 34-37; reprinted in *Hen's Teeth and Horse's Toes*, New York: W.W. Norton, 1994, 253-262.

Head, K., and T. Mayer (2014): "Gravity Equations: Workhorse, Toolkit, and Cookbook," in G. Gopinath, E. Helpman, and K. Rogoff (eds.): *Handbook of International Economics*, Vol. 4, Elsevier.

References V

HEAD, K., AND J. RIES (2001): "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, 91(4), 858–876.

HELPMAN, E. (1987): "Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries," *Journal of the Japanese and International Economies*, 1(1), 62 – 81.

JACKS, D. S., C. M. MEISSNER, AND D. NOVY (2008): "Trade Costs, 1870-2000," *American Economic Review*, 98(2), 529–34.

JONES, R. W. (1965): "The Structure of Simple General Equilibrium Models," *Journal of Political Economy*, 73(6), 557–572.

JONES, R. W., AND J. A. SCHEINKMAN (1977): "The Relevance of the Two-Sector Production Model in Trade Theory," *Journal of Political Economy*, 85(5), 909–935.

KELLER, W., AND S. R. YEAPLE (2013): "The Gravity of Knowledge," *American Economic Review*, 103(4), 1414–1444.

KIMURA, F., AND H.-H. LEE (2006): "The Gravity Equation in International Trade in Services," *Review of World Economics*, 142(1), 92–121.

References VI

KLEINERT, J., AND F. TOUBAL (2010): "Gravity for FDI," *Review of International Economics*, 18(1), 1–13.

KRUGMAN, P. (1980): "Scale Economies, Product Differentiation, and the Pattern of Trade," *American Economic Review*, 70(5), 950–959.

KRUGMAN, P. R. (1979): "Increasing Returns, Monopolistic Competition, and International Trade," *Journal of International Economics*, 9(4), 469–479.

LAMORGESE, A., A. LINARELLO, AND F. WARZYNSKI (2014): "Free Trade Agreements and Firm-Product Markups in Chilean Manufacturing," Discussion paper, Aarhus University.

LAWLESS, M., J. P. NEARY, AND Z. STUDNICKA (2019): "Explaining the Volume of South-North Trade in Ireland: Gravity and Firms from the Good Friday Agreement to Brexit," in preparation.

LENDLE, A., M. OLARREAGA, S. SCHROPP, AND P.-L. VÉZINA (2016): "There Goes Gravity: eBay and the Death of Distance," *Economic Journal*, 126(591), 406–441.

MACHADO, J. A., AND J. SANTOS SILVA (2019): "Quantiles via Moments," *Journal of Econometrics* (forthcoming).

References VII

MAGGI, G., M. MRÁZOVÁ, AND J. P. NEARY (2018): "Choked by Red Tape? The Political Economy of Wasteful Trade Barriers," CEPR Discussion Paper No. 12985.

MAYER, T., V. VICARD, AND S. ZIGNAGO (2019): "The Cost of Non-Europe, Revisited," *Economic Policy*, forthcoming.

MCGRATTAN, E. R., AND A. WADDLE (2018): "The Impact of Brexit on Foreign Investment and Production," Federal Reserve Bank of Minneapolis, Research Department Staff Report 542.

MELITZ, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

MRÁZOVÁ, M., AND J. P. NEARY (2017): "Not So Demanding: Demand Structure and Firm Behavior," *American Economic Review*, 107(12), 3835–3874.

——— (2019a): "IO for Export(s)," Working Paper No. 868, Department of Economics, University of Oxford.

——— (2019b): "Selection Effects with Heterogeneous Firms," *Journal of the European Economic Association*, forthcoming.

NOVY, D. (2013): "International Trade without CES: Estimating Translog Gravity," *Journal of International Economics*, 89(2), 271–282.

References VIII

O'Rourke, K. (2019): *A Short History of Brexit: From Brentry to Backstop*. London: Pelican Books.

Portes, R., and H. Rey (2005): "The Determinants of Cross-Border Equity Flows," *Journal of International Economics*, 65(2), 269–296.

Sampson, T. (2017): "Brexit: The Economics of International Disintegration," *Journal of Economic Perspectives*, 31(4), 163–84.