第六讲 静态优化应用：引力方程

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本讲主要内容

1. 引力方程

1.1 国际贸易的特征事实

1.2 引力模型和引力方程

1.3 Anderson and van Wincoop(2003)

1.4 参考文献

2. 文献阅读

特征事实：国际贸易

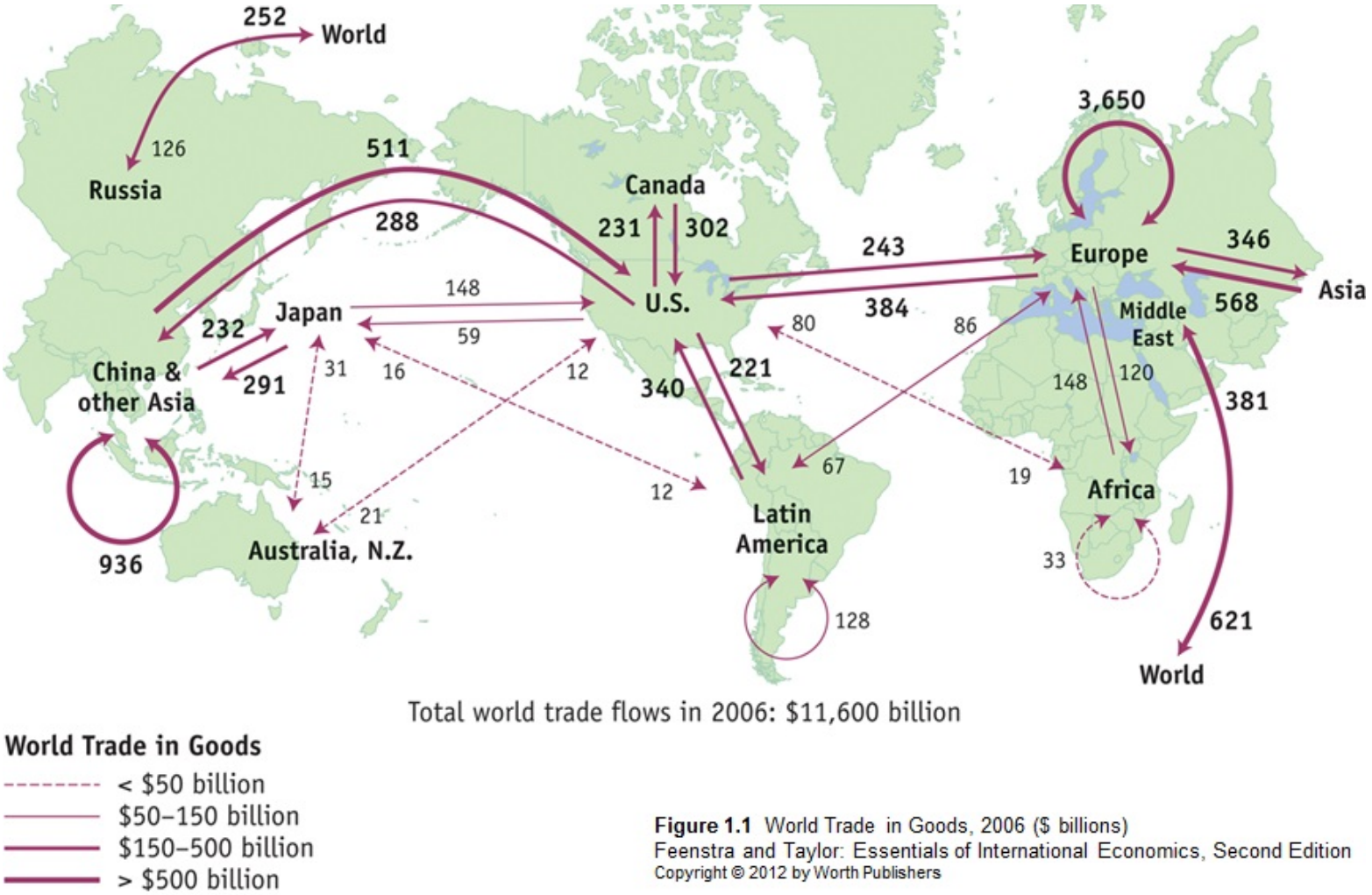


Figure 1.1 World Trade in Goods, 2006 ($ billions)
Feenstra and Taylor: Essentials of International Economics, Second Edition

特征事实：贸易量与经济规模正相关

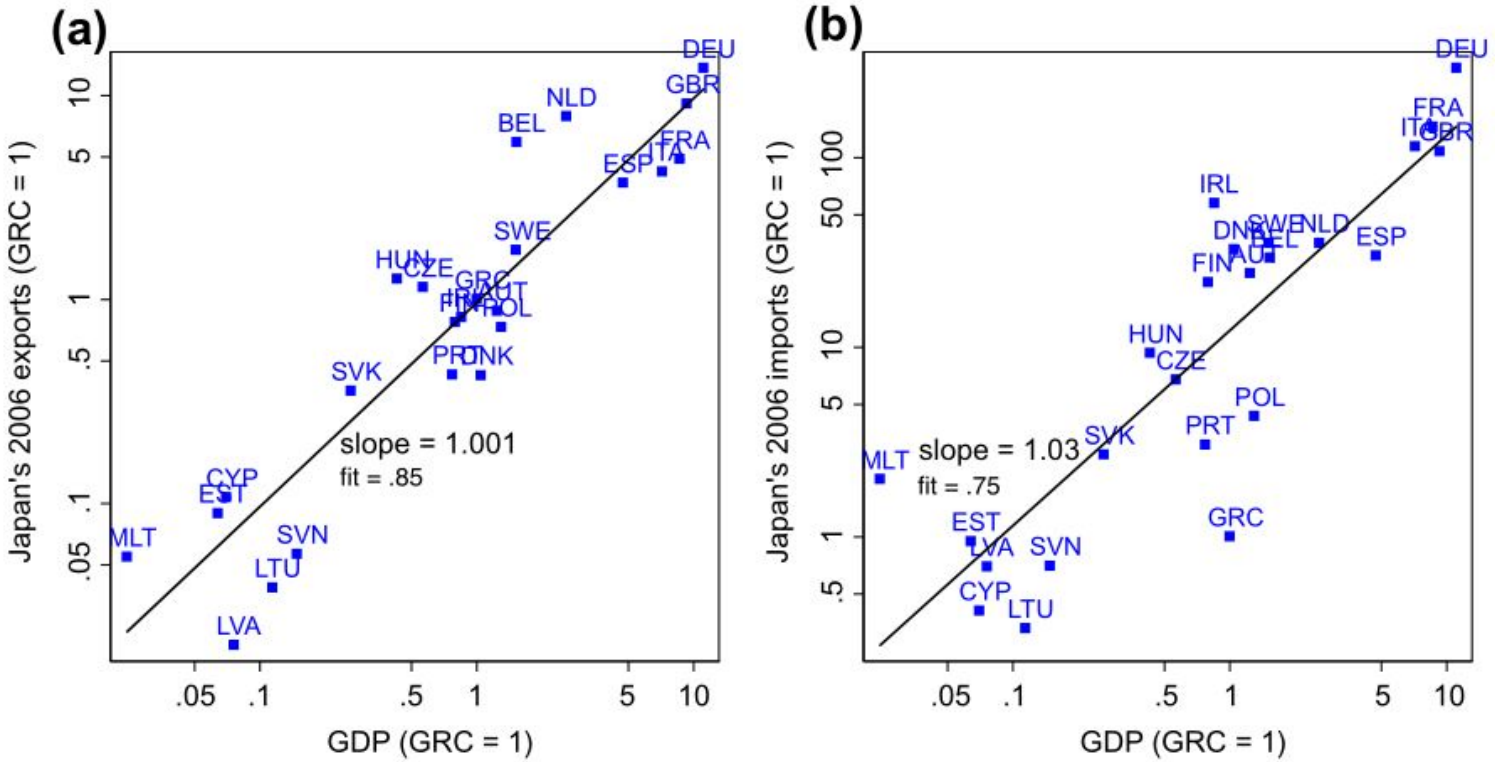


Figure 3.1 Trade is Proportional to Size; (a) Japan's Exports to EU, 2006; (b) Japan's Imports from EU, 2006. GRC: Greece

Source: Head and Mayer(2014).

特征事实：贸易量与距离负相关

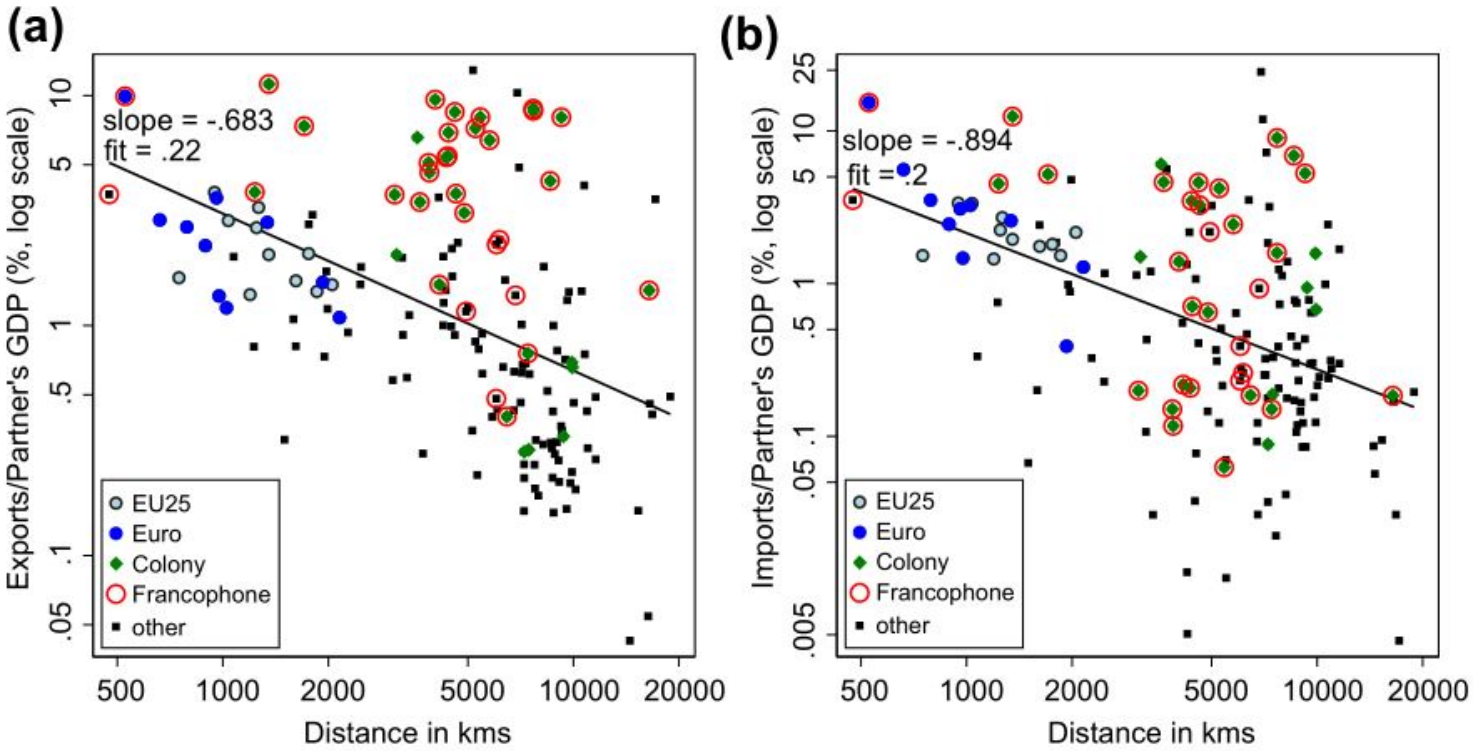


Figure 3.2 Trade is Inversely Proportional to Distance; (a) France's Exports (2006); (b) France's Imports (2006)

Source: Head and Mayer(2014).

相关应用：国际移民

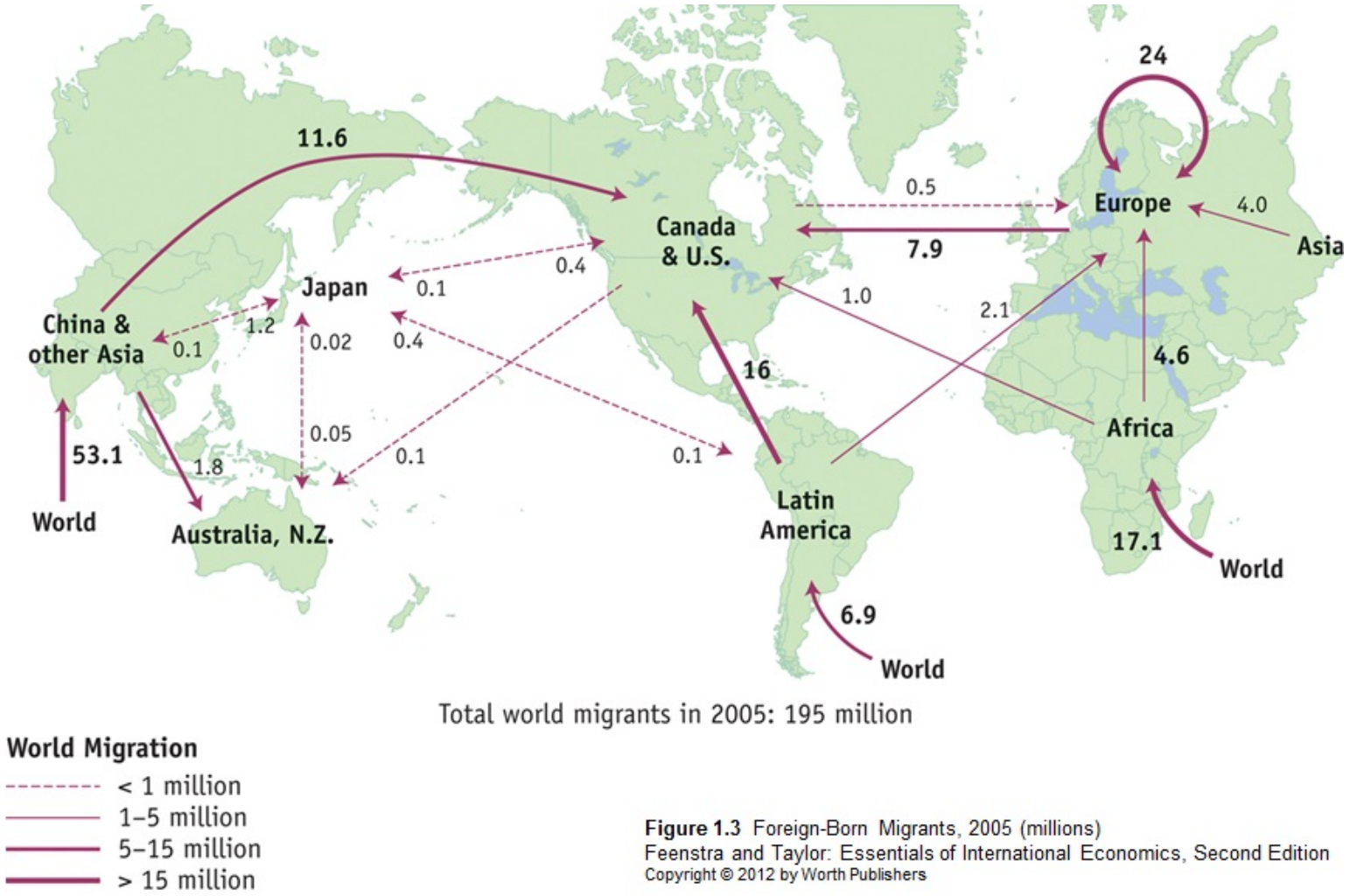


Figure 1.3 Foreign-Born Migrants, 2005 (millions)
Feenstra and Taylor: Essentials of International Economics, Second Edition

相关应用：国际直接投资

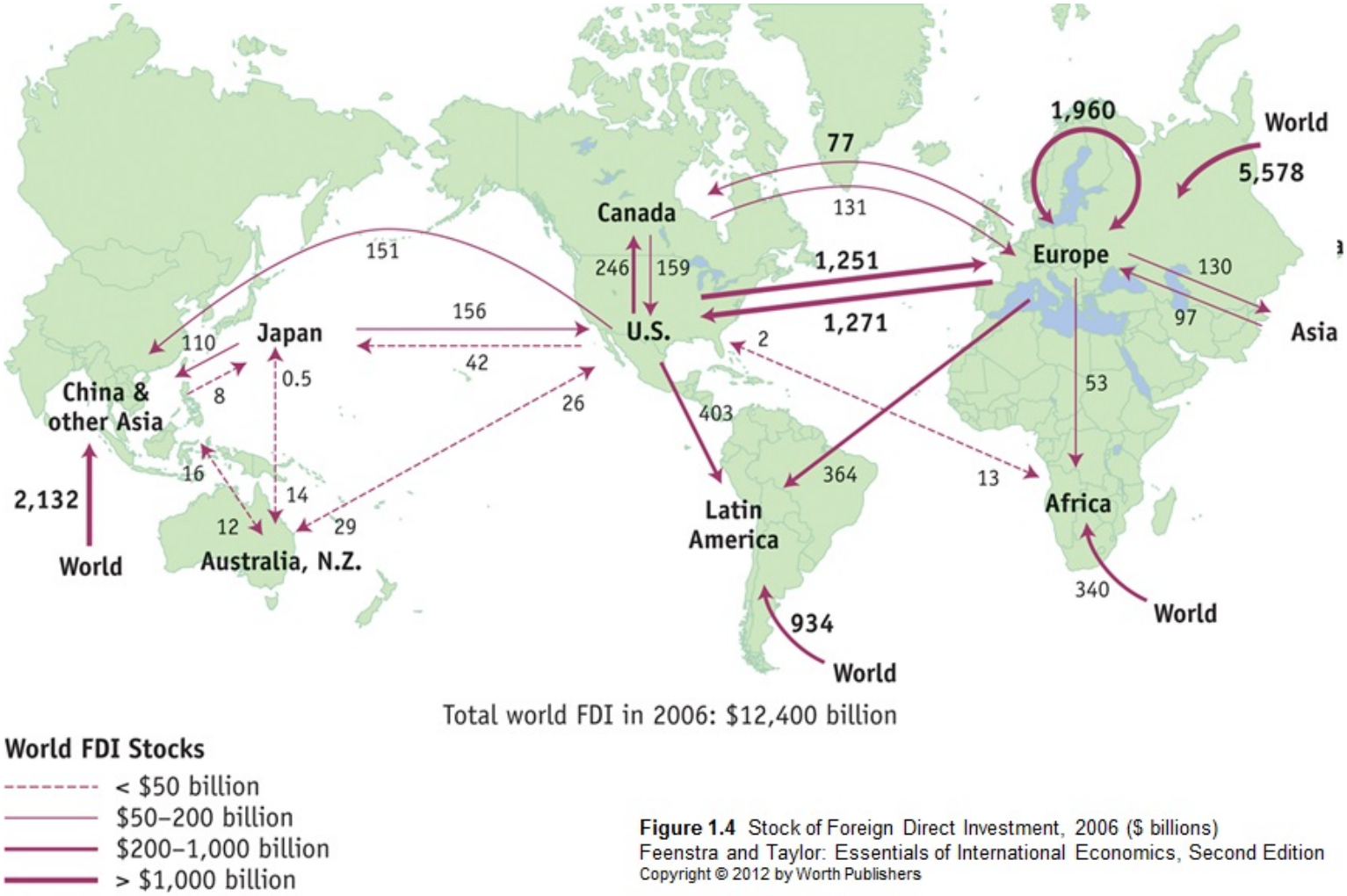
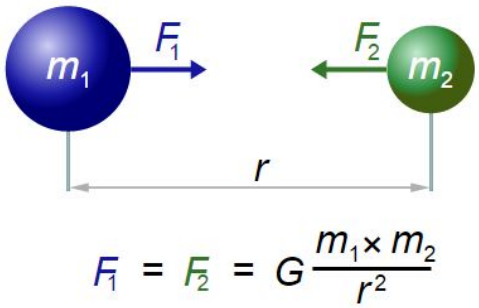


Figure 1.4 Stock of Foreign Direct Investment, 2006 ($ billions)
Feenstra and Taylor: Essentials of International Economics, Second Edition

引力模型和引力方程

- Newton's law of universal gravitation



- Gravity Model: Basic gravity models state that economic interactions between two geographically defined entities are proportional to the size of these entities and inversely related to the distance between them. They have great empirical explanatory power.
- Head and Mayer(2014): three definitions of the gravity equation
  - General gravity $x_{ij} = GS_iM_j\phi_{ij}$
  - Strutural gravity $x_{ij} = \frac{y_i}{\Omega_i}\frac{x_j}{\Phi_j}\phi_{ij}$
  - Naive gravity equation $x_{ij} = Gy_i^a y_j^b \phi_{ij}$

McCallum(1995)的实证研究

$$\ln x_{ij} = \alpha_1 + \alpha_2 \ln y_i + \alpha_3 \ln y_j + \alpha_4 \ln d_{ij} + \alpha_5 \delta_{ij} + \alpha_6 REM_i + \alpha_7 REM_j + \varepsilon_{ij}$$

- x_{ij} 为地区 i 向地区 j 的出口；
- y_i，y_j 为两个地区的国内生产总值；
- d_{ij} 为两个地区的距离；
- δ_{ij} 表示两个地区是否同属于一个国家（或某种经济联盟等）的哑变量，边境效应等于 $e^{\delta_{ij}}$；
- $REM_i = \sum_{m \neq j} \frac{d_{im}}{y_m}$。

	McCallum regressions			Unitary income elasticities		
Data	(i) CA–CA CA–US	(ii) US–US CA–US	(iii) US–US CA–CA CA–US	(iv) CA–CA CA–US	(v) US–US CA–US	(vi) US–US CA–CA CA–US
Independent variable						
ln y_i	1.22 (0.04)	1.13 (0.03)	1.13 (0.03)	1	1	1
ln y_j	0.98 (0.03)	0.98 (0.02)	0.97 (0.02)	1	1	1
ln d_{ij}	−1.35 (0.07)	−1.08 (0.04)	−1.11 (0.04)	−1.35 (0.07)	−1.09 (0.04)	−1.12 (0.03)
Dummy–Canada	2.80 (0.12)		2.75 (0.12)	2.63 (0.11)		2.66 (0.12)
Dummy–U.S.		0.41 (0.05)	0.40 (0.05)		0.49 (0.06)	0.48 (0.06)
Border–Canada	16.4 (2.0)		15.7 (1.9)	13.8 (1.6)		14.2 (1.6)
Border–U.S.		1.50 (0.08)	1.49 (0.08)		1.63 (0.09)	1.62 (0.09)
$\bar{R}^2$	0.76	0.85	0.85	0.53	0.47	0.55
Remoteness variables added						
Border–Canada	16.3 (2.0)		15.6 (1.9)	14.7 (1.7)		15.0 (1.8)
Border–U.S.		1.38 (0.07)	1.38 (0.07)		1.42 (0.08)	1.42 (0.08)
$\bar{R}^2$	0.77	0.86	0.86	0.55	0.50	0.57

Anderson and van Wincoop(2003)的质疑和贡献

Gravity equations have been widely used to infer trade flow effects of various institutional arrangements. We show that estimated gravity equations do not have a theoretical foundation. This implies both that estimation suffers from omitted variables bias and that comparative statics analysis is unfounded. We develop a method that (i) consistently and efficiently estimates a theoretical gravity equation and (ii) correctly calculates the comparative statics of trade frictions. We apply the method to solve the famous McCallum border puzzle. Applying our method, we find that national borders reduce trade between industrialized countries by moderate amounts of 20-50 percent.

引力方程的理论基础

$$Max\ u_j = \left(\sum_i (c_{ij}/\beta_i)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$
$$s.t. \sum_i p_{ij}c_{ij} = y_j = \sum_i x_{ji}$$

由一阶条件和预算约束条件可知地区 i 出口到地区 j 的贸易量为（原文6式）：

$$x_{ij} = p_{ij}c_{ij} = \left(\frac{\beta_i p_{ij}}{P_j}\right)^{1-\sigma} y_j$$

假定 $p_{ij} = p_i t_{ij}$、$t_{ij} = b_{ij}d_{ij}^{\rho}$，并记$\theta_i = y_i/y^W$，经过推导可得到下面的结构性引力方程（structural gravity equation，原文9 式）：

$$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}$$

其中：$P_j = \left(\sum_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma}\theta_i\right)^{\frac{1}{1-\sigma}}$、$\Pi_i = \left(\sum_j \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\theta_j\right)^{\frac{1}{1-\sigma}}$

估计结果

根据结构性引力方程，两个地区之间的贸易量受到规模因素 S_{ij}、距离因素 D_{ij} 和非距离的其他阻力（resistance terms） R_{ij}的影响：

$$\ln x_{ij} = \underbrace{\ln y_i + \ln y_j - \ln y^W}_{S_{ij}} + \underbrace{\alpha_1 \ln d_{ij}}_{D_{ij}} + \underbrace{\alpha_2 \left(\delta_{ij} - \ln \Pi_i - \ln P_j\right)}_{R_{ij}}$$

原文中（25）和（26）式把边境效应（border effects）定义为出口国的边境对两国贸易的影响：

$$Border_i = \exp\left(R_{ii} - R_{ij}\right) = \left(\frac{e^{\delta_{ij}} P_i}{P_j}\right)^{\sigma-1}$$

	Two-country model		Multicountry model	
	Canada	US	Canada	US
Theoretically consistent estimate	10.5	2.56	10.7	2.24
	(1.16)	(0.13)	(1.06)	(0.12)
McCallum parameter implied by theory	16.5	1.64	14.8	1.63
	(1.63)	(0.09)	(1.32)	(0.10)

Head and Mayer(2014)：三种估计方法的比较

Abbrev.	Description	Dist.	RTA
OLS	Linear-in-logs with GDPs Tinbergen(1962)	−0.836 (0.021) [0.051]	0.276 (0.063) [0.114]
SILS	Structurally Iterated Least Squares Anderson and van Wincoop(2003)	−0.937 (0.021) [0.058]	0.749 (0.060) [0.176]
LSDV	Least squares w/country dummies Harrigan(1996)	−1.000 (0.021) [0.021]	0.501 (0.058) [0.059]

Notes: Top value in each cell is the mean estimate (based on 1000 repetitions). The true parameters are -1 for distance and .5 for RTA. Average standard error in "( )" and standard deviation of estimate in "[ ]" .

参考文献

- Anderson, J.E. and E. van Wincoop 2003: Gravity and gravitas: a solution to the border puzzle, *American Economic Review*, Vol.93, No.1, P170-192
- Head, K. and T. Mayer 2014: Gravity equations: workhorse, toolkit, and cookbook, Chapter 3 in G. Gopinath, E. Helpman and K. Rogoff (eds), *Handbook of International Economics(Vol.4)*, Elsevier

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- Herrendorf B., R. Rogerson and A. Valentinyi 2013: Two perspectives on preferences and structural transformation, *American Economic Review*, Vol.103(7), P2752-89
- Desmet K. and E. Rossi-Hansberg 2013: Urban accounting and welfare, *American Economic Review*, Vol.103(6), P2296-2327