



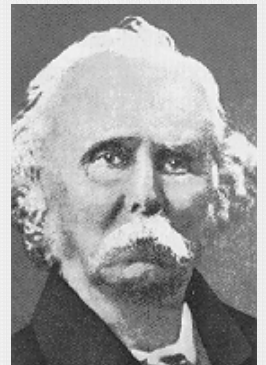
Using Productivity Modeling to Assess Regional Advantage

ST&E Policy Lab
Research Methods Seminar
April 2, 2009

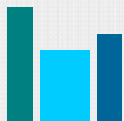
Joshua Drucker
University of Illinois at Chicago

Regional Advantage

- **Regional (dis-)advantage:** extent to which external environment benefits (hinders) performance
- **Agglomeration economy:** advantages based on location in or near a confluence of activity
 - when occurring across businesses: **spillovers** or **external economies** or **externalities**
- Marshall: 3 types
 - shared customers and suppliers
 - shared pool of labor
 - technology and knowledge spillovers
- Others: capital financing, government support, linkages
- Disagglomeration: congestion, pollution, land prices



Alfred Marshall



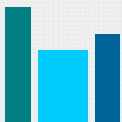
Studying Agglomeration Economies

Questions

- Do they exist?
- How important are they?
- Which sources are most influential?

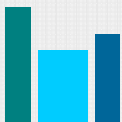
To find answers...

- Business performance relative to environment
- Productivity as measure of performance



Productivity Modeling Approach

- Examine range of business environments
- Assess systematic variation in business performance
- Evaluate relationship between variation in business performance and variation in regional characteristics



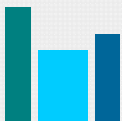
Production Function

Standard microeconomics production function:

$$Q = f(K, L)$$

or slightly more complex,

$$Q = f(K, L, E, \dots)$$



Regional Production Function

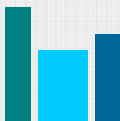
Add regional characteristics in one of 2 ways:

1) Hicks-neutral

$$Q = f(K, L, \dots) \cdot g(Z_1, Z_2, \dots)$$

2) Factor-augmenting

$$Q = h(K, L, E, \dots, Z_1, Z_2, \dots)$$

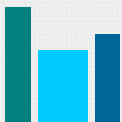


Why a Production Function?

Could use ordinary least squares regression:

- dependent variable: Q (output)
- independent variables:
 - standard inputs: K, L, \dots
 - regional characteristics: Z_1, Z_2, \dots

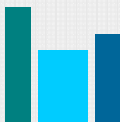
Could use other statistical techniques, either parametric or nonparametric



Reasons to Use Production Function

Production function specifies nature of relationship between inputs and output

- provides strong theory behind relationship
- adds information (statistical strength)



Functional Form

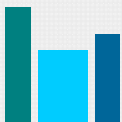
1) Cobb-Douglas $Q = A \sum_i X_i^{\gamma_i}$

2) Constant Elasticity of Substitution (CES)

$$Q = B \left(\sum_i \theta_i X_i^{-\rho} \right)^{-v/\rho} \quad \text{where} \quad \sum_i \theta_i = 1$$

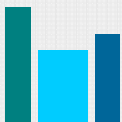
3) Transcendental Logarithmic

$$\ln Q = \alpha_0 + \sum_i \alpha_i \ln X_i + \frac{1}{2} \sum_i \sum_j \beta_{ij} (\ln X_i \ln X_j)$$



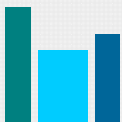
Measuring Agglomeration Economies

- external economies cannot be measured directly
- estimate potential agglomeration economies
- empirics has fallen behind theory



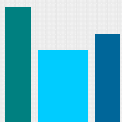
Research Approach

- Establish model
- Gather data
- Measure agglomeration
- Estimate restricted model
- Evaluate and interpret coefficients of variables of interest



Aggregate Regional Production Functions – Procedure

- define industry (e.g., 2- or 3-digit NAICS)
- each region is one observation
- agglomeration economies indicated by
 - regional size (employment or population)
 - regional density (employment or population)
 - manufacturing employment or density
 - urbanized proportion of region
- estimate parameters for industry across regions

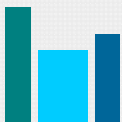


Aggregate Regional Production Functions – Empirical Work

Numerous examples throughout regional economics and regional science literatures in 1970s, 1980s, 1990s

Find production positively associated with

- greater size
- greater density, urbanization
- larger or more concentrated manufacturing sector
- holds across industrialized nations



Meta-Study (Melo et al. 2009)

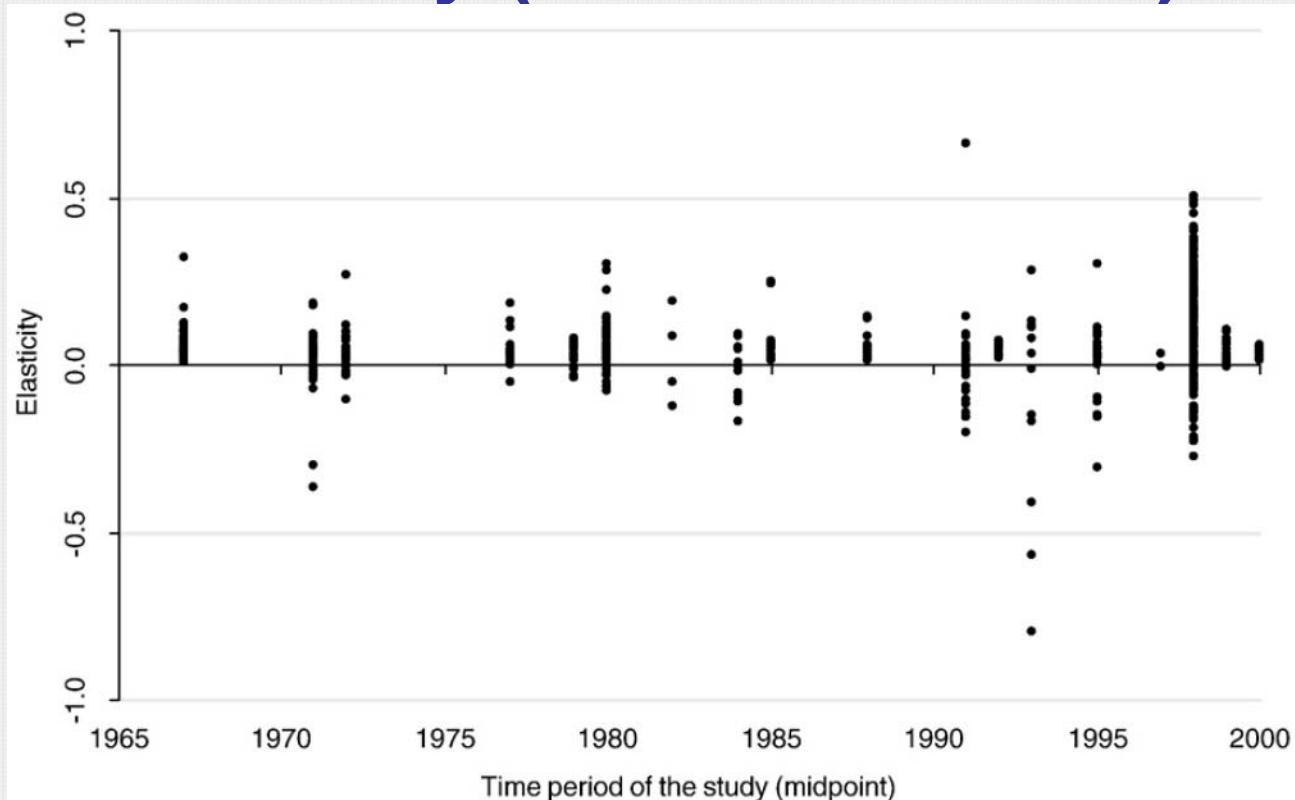


Fig. 1. Distribution of the elasticity estimates over the time period of the study (midpoint).

Melo, P. C., D. J. Graham, and R. B. Noland. 2009. A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics*, 39 (3): 332-342. (p. 336).

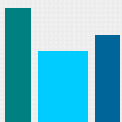
Aggregate Regional Production Functions – Assessment

Advantages

- relatively simple execution
- publicly available data (mostly)

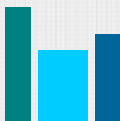
Disadvantages

- crude proxies – lump all agglomeration together
- ecological fallacy (aggregation bias)
- no capital data



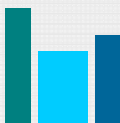
Establishment-Level Production Functions – Procedure

- define industry (at 3- to 6-digit NAICS)
- each establishment is one observation
- create variables for
 - regional characteristics
 - agglomeration
- estimate parameters for industry across regions



Establishment-Level Production Functions – Empirical Work

- Studies appear in late 1990s and into 2000s
- Examine U.S., Brazil, China, United Kingdom, India, Italy, Japan
- Findings vary more than for aggregate approach
 - increased variation in constructed measures
 - multicollinearity in agglomeration and other regional indicators
- Labor pooling most often positive and significant of Marshall's 3 – perhaps easiest to measure
- Small, independent plants benefit more than large or branch plants



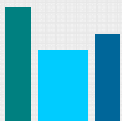
Establishment-Level Production Functions – Assessment

Advantages

- microeconomic theory applies better at plant level
- capital data exists
- avoids aggregation bias
- can better model agglomeration economies

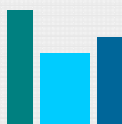
Disadvantages

- much more complex models
- data confidentiality



Key Specifications

- 3 manufacturing industries
- 5 different agglomeration variables
 - labor pooling
 - 2 input pooling (manufactures, services)
 - 2 knowledge spillovers (university, patenting)
- plant and regional control variables



Translog production function system

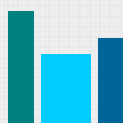
- translog production function equation

$$\ln Q = \alpha_0 + \sum_i \alpha_i \ln X_i + \frac{1}{2} \sum_i \sum_j \beta_{ij} (\ln X_i \ln X_j) \\ + \sum_k \gamma_k \ln Z_k + \sum_i \sum_k I(i, k) \lambda_{ik} \ln X_i \ln Z_k + \sum_k \sum_l I(k, l) \lambda_{kl} \ln Z_k \ln Z_l$$

- derived factor share equations (i=K,L,M)

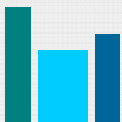
- technique: iterated seemingly unrelated regression (ITSUR)

- SAS: Proc Model command



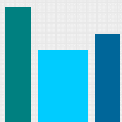
Fully Specified Production Function

$$\begin{aligned}
 \ln Q = & \alpha_0 + \alpha_k \ln K + \alpha_l \ln L + \alpha_e \ln E + \alpha_m \ln M \\
 & + \frac{1}{2} \beta_{kk} (\ln K)^2 + \frac{1}{2} \beta_{ll} (\ln L)^2 + \frac{1}{2} \beta_{ee} (\ln E)^2 + \frac{1}{2} \beta_{mm} (\ln M)^2 \\
 & + \beta_{kl} \ln K \ln L + \beta_{ke} \ln K \ln E + \beta_{km} \ln K \ln M \\
 & + \beta_{le} \ln L \ln E + \beta_{lm} \ln L \ln M + \beta_{em} \ln E \ln M \\
 & + \gamma_d D + \gamma_{lp} LP + \gamma_{sp} \ln SP + \gamma_{sd} \ln SD + \gamma_{rs} \ln RS + \gamma_{ps} \ln PS \\
 & + \frac{1}{2} \delta_{dd} (D^2) + \delta_{dlp} (D \cdot LP) + \delta_{dsp} D \ln SP \\
 & + \delta_{dsd} D \ln SD + \delta_{drs} D \ln RS + \delta_{dps} D \ln PS \\
 & + \lambda_{dk} D \ln K + \lambda_{dl} D \ln L + \lambda_{de} D \ln E + \lambda_{dm} D \ln M \\
 & + \lambda_{lpk} LP \ln K + \lambda_{lpl} LP \ln L + \lambda_{lpe} LP \ln E + \lambda_{lpm} LP \ln M \\
 & + \lambda_{spk} \ln SP \ln K + \lambda_{spl} \ln SP \ln L + \lambda_{spe} \ln SP \ln E + \lambda_{spm} \ln SP \ln M \\
 & + \lambda_{sdk} \ln SD \ln K + \lambda_{sdl} \ln SD \ln L + \lambda_{sde} \ln SD \ln E + \lambda_{sdm} \ln SD \ln M \\
 & + \lambda_{rsk} \ln RS \ln K + \lambda_{rsl} \ln RS \ln L + \lambda_{rse} \ln RS \ln E + \lambda_{rsm} \ln RS \ln M \\
 & + \lambda_{psk} \ln PS \ln K + \lambda_{psl} \ln PS \ln L + \lambda_{pse} \ln PS \ln E + \lambda_{psm} \ln PS \ln M \\
 & + v_{de} DE + v_{se} SE + v_{cr1} CR1 + v_{cr2} CR2 + v_{cr3} CR3 \\
 & + v_{pop} \ln POP + v_{ue} UE + v_{inc} \ln INC + v_{dv} DV \\
 & + \rho_{dh} DH + \rho_{dvh} DVH + \varepsilon
 \end{aligned}$$



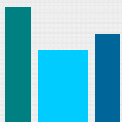
Agglomeration Findings

- labor pooling and supply pooling not very important
- much greater productivity effects from knowledge spillovers
- larger effects in more technology-intensive industries
- industrial structure at regional level does not impact agglomeration benefits much

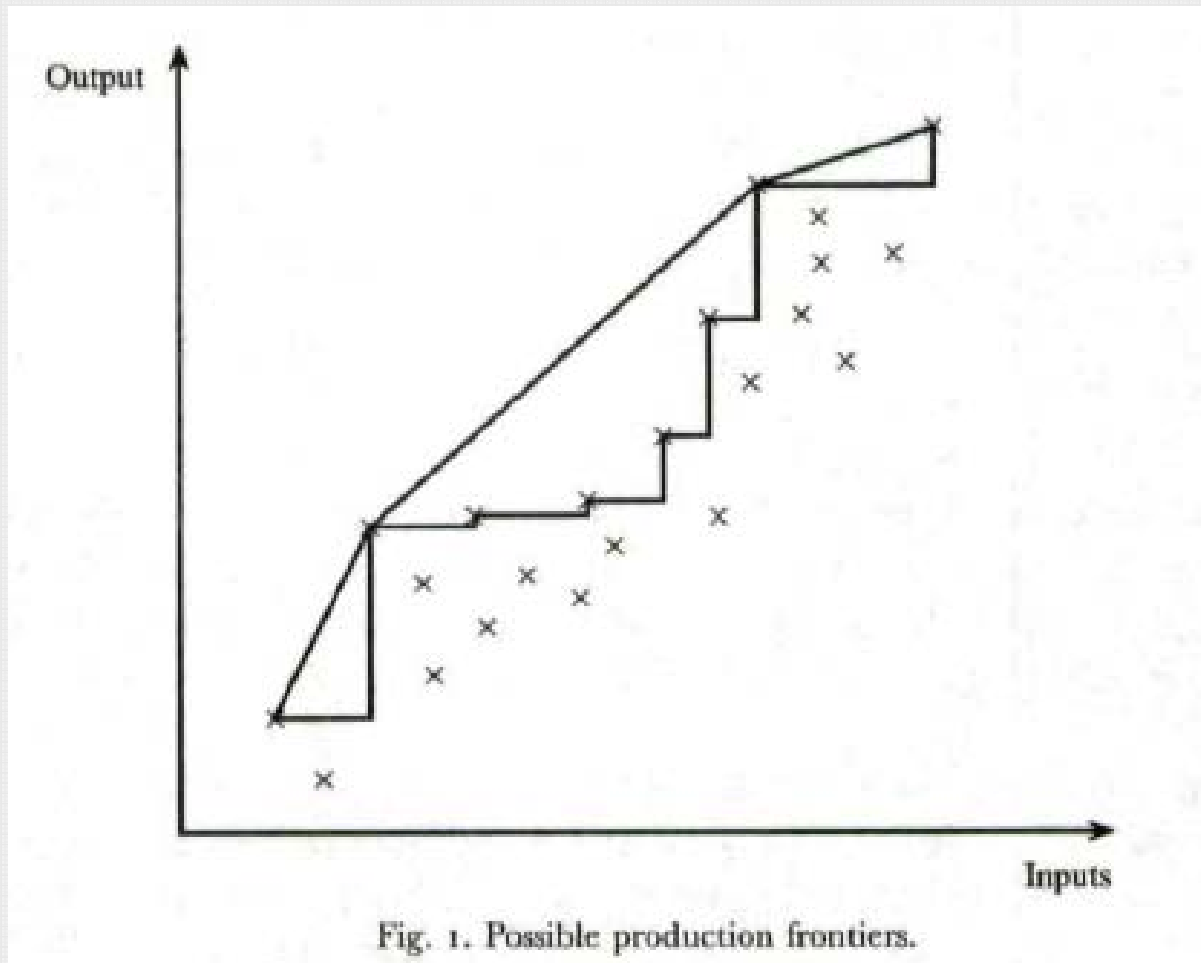


Other Productivity Approaches

- changes in productivity over time (panel data)
- stochastic production possibility frontiers and data envelopment analysis



Data Envelopment Analysis



Green, A., and D. Mayes. 1991. Technical inefficiency in manufacturing industries. *The Economic Journal*, 101 (406): 523-538. (p. 525).