INTERNATIONAL TRADE - ECON 245

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EXTENSIONS OF THE CANONICAL SPATIAL MODEL

INTRODUCTION

- The workhorse “quantitative spatial model” is modular:
  - “Modules“ for producers, consumer, and market structure can be combined arbitrarily
  - Each “modules“ introduces new parameters and new regional fundamentals
    - Fundamentals can always be inferred as structural residuals
- Overall: flexible modeling framework for any quantitative spatial question

PRODUCTION MODULES REVIEW

- We saw four ways to specify the production side:
  - *Rosen-Roback*: homogeneous good produced under perfect competition
  - *Armington*: region-specific variety produced under perfect competition with CES "love for variety" preferences
  - *Eaton Kortum*: Continuum of goods; each region/country has probabilistic productivity at producing each; perfect competition+CES "love for variety" preferences
  - *Krugman*: free entry of firms (varieties) under monopolistic competition with CES "love for variety" preferences

PLAN FOR TODAY

- Today will cover a range of important additional “modules:”
  - Skill types
  - Sectors
  - Rental markets
  - Commuting
  - Input-Output Linkages

GENERAL SETUP

- For convenience assume the same setup throughout (unless otherwise stated)
- Discrete set of N regions
  - Armington economy with region-specific varieties and perfect competition
  - CES preferences over regional varieties
  - Index locations by i, j, individual workers by ω
  - Frechet shocks for location choice, with inverse variance θ and mean 1

SKILL HETEROGENEITY

INTRODUCTION

- Introduce skill types k; for simplicity consider case with high ($k = h$) and low ($k = l$)
- Two ways to make skill enter the canonical spatial model
  1. Worker types enter production function symmetrically
     - Firm production function: $y_i = A_i h_i$ where h_i are *efficiency units of labor* supplied by *either* high- or low-skill workers
  2. Worker types enter production function differently
     - CES production function with two skill types: $y_i = \left(\alpha_h l_{i,h}^{\frac{\rho-1}{\rho}} + \alpha_l l_{i,l}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$

EFFICIENCY UNITS OF LABOR

- Workers differ in their efficiency units of labor; w_i wage per efficiency unit
- Worker ω can provide h^ω units of efficiency labor
  - Workers draw their efficiency units from a Fréchet distribution *after* choosing locations

$$F_k(h) = \exp(-T_k h^{-\vartheta}) \quad \text{where} \quad T_k > 0 \quad \text{and} \quad \vartheta > 1$$

- If $T_h > T_l$ the average high-skill worker supplies more labor units
  - The average wage among workers in each group: $\bar{w}_{i,k} = T_k^{1/\vartheta} w_i$ (via Frechet math)
  - The skilled wage premium is then simply $\bar{w}_{i,h} / \bar{w}_{i,l} = (T_h / T_l)^{1/\vartheta}$

EQUILIBRIUM SKETCH

- The local labor/goods market clearing condition in efficiency units:

$$H_i w_i = \sum_j \lambda_{ij} H_j w_j$$

where we can show that $H_{i,k} = L_{i,k}\Gamma(\theta)T_i^{1/\vartheta}$ and $H_i = H_{i,h} + H_{i,l}$ (Frechet math)

- Separate location choice equations for high and low skill agents:

$$L_{i,k} = \frac{\bar{w}_{i,k}^{\theta}}{\sum_i \bar{w}_{i,k}^{\theta}} \bar{L}_k$$

Expected wages due to uncertainty about skill shocks, received after moving

AN ALTERNATIVE OR ADDITION: CES PRODUCTION FUNCTION

- With CES formulation can either work in bodies or efficiency units

$$\frac{w_{i,h}}{w_{i,l}} = \left(\frac{l_{i,h}}{l_{i,l}}\frac{\alpha_l}{\alpha_h}\right)^{-1/\rho} \quad \text{or} \quad \frac{w_{i,h}}{w_{i,l}} = \left(\frac{h_{i,h}}{h_{i,l}}\frac{\alpha_l}{\alpha_h}\right)^{-1/\rho}$$

Attractive: local skill premium now depends on relative local labor supply

- Now have *separate* local labor markets for high and low skill workers
  - Use skill premium expression to write goods/labor market clearing just in terms of high- or low-skill wage

A NOTE ON SKILL TYPE SPECIFIC AMENITIES

- With CES *production* function local factor supply determines local skill premium
- Locations may differ in the amenities they provide to different skill groups.
- Consider the indirect utility of a type k worker: $W_{i,k} = u_{i,k}\frac{\bar{w}_{i,k}}{P_i}$
- With free mobility $W_{i,k} = \bar{W}_k$, all else equal high amenities entail low wages
- High-skill workers are cheap in New York since it has high skill amenities
  - Part of New York's comparative advantage in producing skill-intensive goods

SECTORS

INTRODUCTION

- The one-sector Armington model is designed to justify *intra*industry trade
- The Ricardian and Heckscher-Ohlin models explained *sectoral* specialization
- We now have the tools to re-introduce sectors into the spatial model
  - Allow for both technology (Ricardian) and factor endowment differences (Heckscher Ohlin) motives for sectoral specialization
    - With Armington setup: never complete specialization, but always net importer in at least one sector, and net exporter in another

INTRODUCING SECTORS

- Regions have two sectors s; each produce a unique Armington variety
- Consumer spend fraction α_s on sectors s Armington bundle
- Locations differ in the sector-specific productivities $A_{r,s}$ (Ricardo!)
- Each sector requires efficiency units of labor to produce:

$$y_{r,s} = A_{r,s} h_{r,s}$$

- Efficiency units can be supplied by high- or low-skill workers alike
  - Wage per efficiency unit ($w_{r,s}$) differs across sectors, not skill types since workers are perfectly substitutable in production function, but not across sectors

SECTORS AND SKILLS

- Within each skill group, workers differ in their productivity for each sector
  - *Idiosyncratically:* some workers are better in some sector
  - *Systematically:* high-skill workers are better in some sector
- Worker draw the efficiency units of labor they can supply from Fréchet distribution:

$$F_{s,k}(h) = \exp(-T_{s,k}h^{-\vartheta}) \quad T_{s,k} > 0 \quad \vartheta > 1$$

  - Skilled workers have an *absolute advantage* $T_{h,s} > T_{l,s}\ \forall s$
  - Workers have a *comparative advantage* in one sector $T_{h,1}/T_{h,2} > T_{l,1}/T_{l,2}$

SECTOR CHOICES AND SECTORAL LABOR SUPPLY IN EFFICIENCY UNITS

- The fraction of workers of each skill type that choose a given sector:

$$\phi_{i,k,s} = \frac{T_{k,s}(w_{i,s})^{\vartheta}}{\sum_{s'} T_{k,s}(w_{i,s'})^{\vartheta}} \quad \text{and} \quad H_{i,k,s} = L_{i,k}\Gamma(\vartheta)T_{k,s}^{1/\vartheta}\phi_{i,k,s}^{\frac{\vartheta-1}{\vartheta}}$$

- Holding wages equal:
  - If $T_{h,1}/T_{h,2} > T_{l,1}/T_{l,2}$ larger fraction of h workers choose $s = 1$ than l workers
  - Comparative advantage drives sector choice; absolute advantage irrelevant!

WAGE DIFFERENCES ACROSS SKILL GROUPS

- "Fréchet math" yields an expression for the average wage by skill type

$$\bar{w}_{i,k} = \left(\sum_{s} T_{k,s} w_{i,s}^{\vartheta} \right)^{1/\vartheta}$$

- With $T_{h,s} > T_{l,s}\ \forall s$, $\bar{w}^h > \bar{w}^l$: absolute advantage drives wage level differences
- Worker type k more exposed to wages changes in sector of comparative advantage
- Skill premium $\bar{w}_{i,h}/\bar{w}_{i,l}$ a function of relative supply and sectoral choices even without CES!

EQUILIBRIUM

- Labor/Goods market clearing equation for each sector:

$$w_{i,s}H_{i,s} = \sum_{j,s'} \lambda_{ij}^{s} \alpha_s w_{j,s'} H_{j,s'}$$

where α_s is spending share on sector s and $H_{i,s}$ total efficiency units in i, s

- Optimal sectoral choices:

$$\phi_{i,k,s} = \frac{T_{k,s}(w_{i,s})^{\vartheta}}{\sum_{s'} T_{k,s'}(w_{i,s'})^{\vartheta}} \quad \text{and} \quad H_{i,k,s} = L_{i,k}\Gamma(\vartheta)T_{k,s}^{1/\vartheta}\phi_{i,k,s}^{\frac{\vartheta-1}{\vartheta}} \quad \text{and} \quad H_{i,s} = \sum_{k} H_{i,k,s}$$

- Optimal Location choices ($u_{i,k}$: Heckscher Ohlin element!)

$$L_{i,k} = \frac{u_{i,k}(\bar{w}_{i,k})^{\theta}}{\sum_{i} u_{i,k}(\bar{w}_{i,k})^{\theta}} \bar{L}_k \quad \text{where} \quad \bar{w}_{i,k} = \left(\sum_{s} T_{k,s} w_{i,s}^{\vartheta} \right)^{1/\vartheta}$$

HORSERACE BETWEEN RICARDO AND HECKSCHER-OHLIN

- Suppose there are two sectors tradable services ($s = TS$) and goods ($s = TG$)
- Then locations that have $A_{i,TS} > A_{i,TG}$ would tend to specialize in goods
- And high skill workers would tend to work in TS if $T_{h,TS}/T_{h,TG} > T_{l,TS}/T_{l,TG}$
- However:
  - If a region with $A_{i,TS} > A_{i,TG}$, has very high low skill amenities, so that low-skill workers are cheap it may still be a net exporter of TG
  - Horse-race between Heckscher-Ohlin and Ricardo motives

RENTAL MARKETS

INTRODUCTION

- A distinctly *spatial* feature of the economy are housing markets
  - They clear locally, in contrast to goods markets
  - Their supply is constrained by local geological features or laws
  - They are key ingredient in differences in cost of living across locations
  - They are a natural "congestion" force in spatial models
  - They are central in regulating access to local amenities and labor markets

PREFERENCES

- The easiest way to introduce housing is a nested structure
  - Cobb Douglas utility with $\alpha \in (0,1)$ the expenditure share on the traded CES bundle
  - The resulting indirect utility from locating in location i is then given:

$$W_i = \frac{w_i}{P_i^{\alpha} r_i^{1-\alpha}}$$

HOUSING SUPPLY: FIXED

- The simplest way is to assume a fixed housing supply H_i in each location
- This changes the good/labor market clearing equation:

$$w_i L_i = \sum_j \lambda_{ij} w_j L_j \alpha (1 + \phi)$$

  - $(1 + \phi)$ explained shortly
- And it adds a local housing market clearing condition to solve for local rents:

$$(1 - \alpha)(1 + \phi) w_i L_i = r_i H_i$$

- α can be obtained from Consumer Expenditure Survey, rent data from Decennial Census or Zillow: can infer H_i as structural residual from housing market clearing!

HOUSING SUPPLY: ELASTIC

- In reality housing supply is liked to adjust if more families move into a location
- A reduced from way of modeling this to specific local housing supply as follows:

$$H_i = \bar{H}_i L_i^{\psi} \quad \text{where usually} \quad \psi \in (0,1)$$

- The concavity in the supply models that as more and more families move in land becomes unavailable
- ψ can be estimated from relationship between Δr_i and ΔL_i using an IV strategy

HOUSING SUPPLY: MICROFOUNDED

- Each location has land area S_i which can be combined with labor to produce housing services/or develop the land to be inhabitable:

$$H_i = (l_i^H)^\beta s_i^{1-\beta} \Rightarrow H_i = (1-\beta) L_i^\beta S_i^{1-\beta}$$

  - where s_i is demand for land in the housing sector, arrow holds in equilibrium only

- Since S_i is a fixed factor: endogenously varying house price elasticities across locations!

- Be careful that labor/goods market clearing changes since there are now two sectors in the economy.

WHO OWNS HOUSING?

- A crucial issues is the ownership of housing: who gets the return on housing $r_i H_i$?
  - Several ways of modeling this:
    - Not a good idea: reimburse housing income to all local agents since this distorts location choices
    - National portfolio of housing in which everyone owns a share proportional to their income:

$$\sum_i w_i L_i \phi = \sum_i r_i H_i \Rightarrow \phi = \frac{\sum_i r_i H_i}{\sum_i w_i L_i}$$

    - The total income of an agent is then $(1 + \phi) w_i$

WHO OWNS HOUSING?

- Other ways of modeling housing ownership:
  - Introduce second type of agent which cannot move and doesn't rent housing themselves just consumes goods: landlords
    - So that $r_i H_i$ is simply spent in location i on tradable goods
  - Very few papers thinking seriously about ownership of housing by individuals!

HOUSE PRICE ELASTICITIES AS AN INSTRUMENT

- Albert Saiz in the QJE: "The Geographic Determinants of Housing Supply"
  - Satellite data on terrain elevation and presence of water bodies to precisely estimate the amount of developable land in U.S. metropolitan areas.
  - Shows directly that "most areas in which housing supply is regarded as inelastic are severely land constrained by their geography"
    - Takeaway: "Geography is a key factor in the contemporaneous urban development of the United States"
- Widely used as an instrument: exogenous variation in Δr_i given ΔL_i!

FURTHER READING

- Hsieh Moretti 2018 (AEJ Macro): housing market restriction reduce US economic growth by preventing workers moving into most fast growing locations
- Ganong and Shoag 2017 (JUE): housing market restrictions deter low-skill migration into high-paying cities
- Ahlfeldt, Redding, Sturm, Wolf 2015 (ECMA): the impact of the building of the Berlin wall on the rent price gradient in the city
- Couture Gaubert Handbury Hurst 2019: displacement of poor workers in big cities as income inequality drives up the prices of housing in certain locations

COMMUTING

INTRODUCTION

- Migration is not the only way to access a productive labor market
  - Commuting provide an additional means of access that avoids paying the high cost of rent typically associated with productive locations
- Commuting infrastructure is a huge policy concern
  - The United States is largely specialized in “car accessibility” whereas Europe has greater “transit” accessibility.
- Commuting also matters for labor market, elasticity of local employment to a labor demand shock is heterogeneous depending on commuting openness

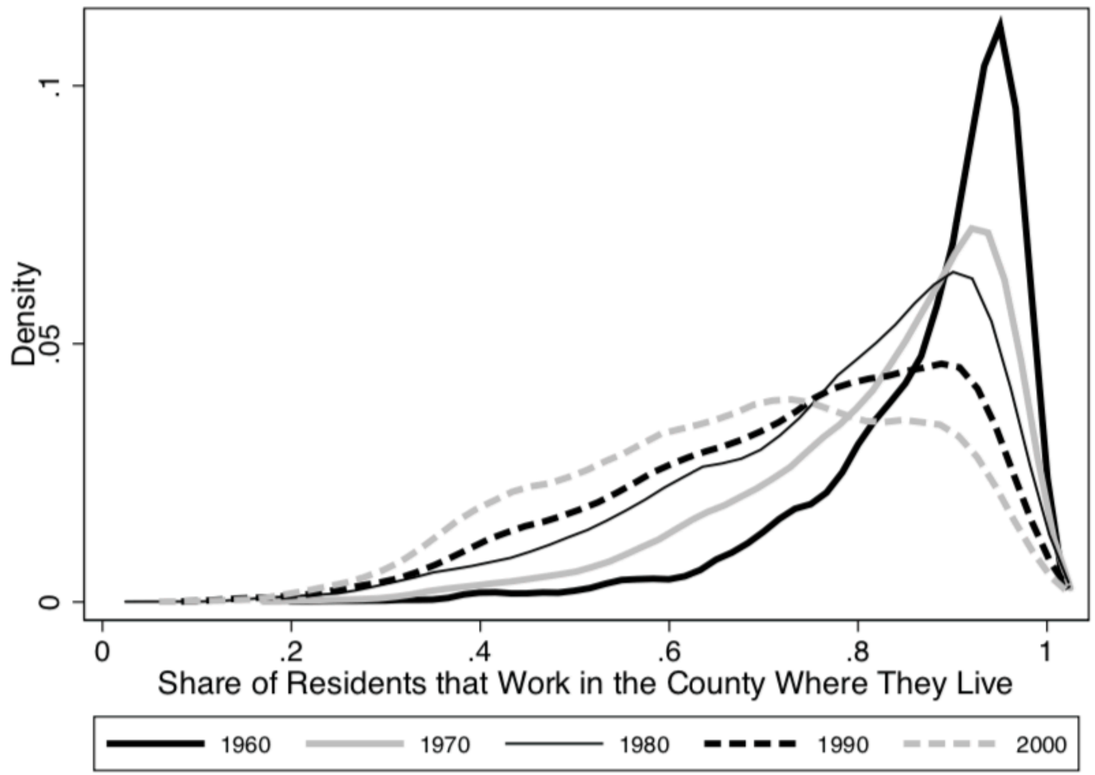
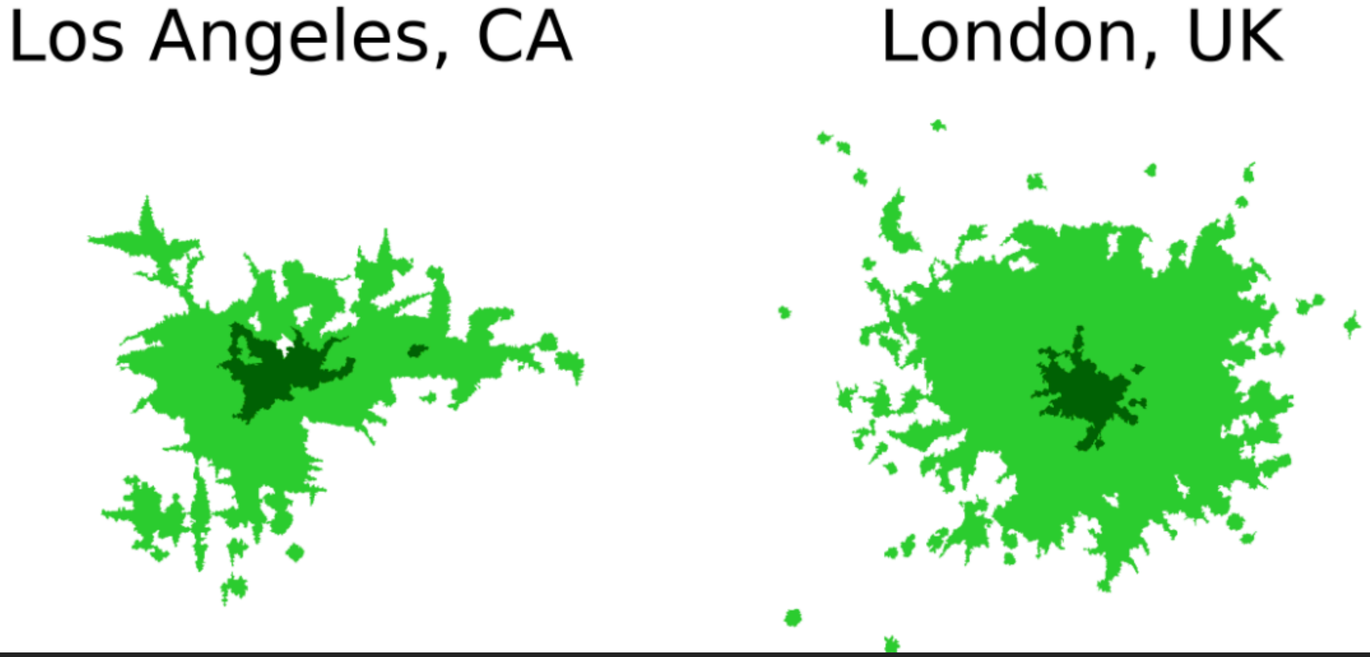


Figure 1: Kernel densities of the share of residents that work in the county where they live

Monte, Redding, Rossi-Hansberg, 2018

FIGURE 1: PUBLIC TRANSIT ACCESSIBILITY ZONES
(30 MINUTES IN DARK, 60 MINUTES IN LIGHT)



Conwell, Eckert, Mobarak, 2021

SETUP

- Cobb Douglas utility over a CES bundle of traded varieties, and local housing services
- Workers now choose *both* their location of residence and of work
  - Workers consume housing and amenities in the location in which they live
  - Workers command the wage associated with their location of work
  - Commuting cost incurred when working and residence location different
- Assume there are landlords in each location which own all land and spend all their income on the traded CES bundle

COMMUTING/LOCATION DECISION

- Worker ω derives the following indirect utility from living in i and working in j:

$$W_{ij}^{\omega} = \frac{\eta_{ij}^{\omega}}{\kappa_{ij}} \frac{w_j}{P_i^{\alpha} r_i^{1-\alpha}}$$

- Note i index on cost of living and j index on wages!
- Also:
  - η_{ij}^{ω} is an idiosyncratic preference shock for the ij combination
  - κ_{ij} is a commuting cost, so that $\kappa_{ii} = 1 \, \forall i$ and $\kappa_{ij} > 1 \, \forall i \neq j$

COMMUTING/LOCATION DECISION

- Workers than solve the the following problem:

$$\max_{ij} \{ W_{ij}^{\omega} \}$$

- To get convenient aggregation we assume η_{ij}^{ω} is Frechet distributed with mean 1 and inverse dispersion parameter θ.

- The fraction of workers making each residence-workplace decision:

$$\phi_{ij} = \frac{(\kappa_{ij} P_i^{\alpha} r_i^{1-\alpha})^{-\theta} w_j^{\theta}}{\sum_{i,j} (\kappa_{ij} P_i^{\alpha} r_i^{1-\alpha})^{-\theta} w_j^{\theta}} \equiv \frac{\Phi_{ij}}{\Phi}$$

EQUILIBRIUM

- Labor/Goods Market Clearing:

$$L_i^W w_i = \sum_j \lambda_{ij} \bar{w}_j L_j^R (1+\phi)\alpha$$

where $\bar{w}_i = \sum_j [w_j \phi_{ij} / (\sum_j \phi_{ij})]$ is the average wage among i residents

- The number of workers and residents in each location is given respectively:

$$L_i^W = \sum_i \phi_{ij} \bar{L} \quad \text{and} \quad L_i^R = \sum_j \phi_{ij} \bar{L}$$

- Housing markets in each location clear: $L_i^R \bar{w}_i (1-\alpha)(1+\phi) = H_i r_i$

FURTHER READING

- Parro, Redding, Rossi-Hansberg 2018 (AER): introduce the extreme value commuting formulation
- Tsivanidis 2019 (JMP): studies the distributional effects of a rapid bus system in Bogota on workers' labor market access and firms' labor market access
- Severen (2021): housing market effects of mass transit infrastructure project in Los Angeles
- Ahlfeldt, Redding, Sturm, Wolf 2015 (ECMA): Impact of the building of the Berlin wall on location of economic activity in the city

INPUT–OUTPUT LINKAGES

INTRODUCTION

- So far all trade was in final goods – however trade in intermediate inputs is very important in the U.S. economy
- Gross output is almost double GDP (value added) in the U.S. economy
  - A lot of trade between US regions and in the world is hence intermediate input trade instead of trade in final goods/services
- Trade economists have developed a concise framework for thinking about input-output linkages between sectors and regions

PRODUCTION

- Suppose the firm production function in location i sector s is given by:

$$y_{i,s} = l_{is}^{\alpha_s} \prod_{s'} [(\sum_{i} q_{i,s'}^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}]^{\gamma_{s's}(1-\alpha_s)} \quad \text{where} \quad \sum_{s'} \gamma_{s's} = 1$$

Value added share of output is α_s intermediate input share of sector s' is $\gamma_{s's}(1-\alpha_s)$

- The price of the Armington variety produced in location i and sector s is given:

$$p_{i,s} = (w_{i,s}/A_{i,s})^{\alpha_s} \prod_{s'} P_{i,s'}^{\gamma_{s's}(1-\alpha_s)}$$

CLOSING THE MODEL

- Consumers have Cobb Douglas preferences *across sectors* and spend β_s on each sector s CES bundle of Armington varieties
- Workers choose locations subject to an idiosyncratic preference shock, and sectors subject to an idiosyncratic productivity shock
  - When choosing location workers take expectations over their sectoral shocks, i.e., sectoral productivity shocks realized after migration decision

EQUILIBRIUM

- Labor/Goods market clearing:

$$H_{i,s}w_{i,s} = \alpha_s \sum_j \lambda_{ij}^s [\beta_s (\sum_s H_{j,s}w_{j,s}) + (\sum_{s'} \gamma_{ss'}(1-\alpha_s)Y_{j,s'})]$$

Note how workers receive only α_s share of total spending on the sector

- Sector choice equation:

$$L_{i,s} = \frac{T_s(w_{i,s})^\vartheta}{\sum_{s'} T_{s'}(w_{i,s'})^\vartheta} L_i$$

- Location choice equation:

$$L_i = \frac{\bar{w}_i^\theta}{\sum_i \bar{w}_i^\theta} \bar{L} \quad \text{where} \quad \bar{w}_i = (\sum_{s'} T_{s'}(w_{i,s'})^\vartheta)^{1/\vartheta}$$

FURTHER READING

- Caliendo and Parro 2018 (RESTUD): Classic paper introducing input-output linkages into quantitative model of trade a la Eaton Kortum (2002) without labor mobility
- Lee 2020 (JIE): nice paper adding occupations to IO analysis
- Caliendo Parro Dvorkin 2019 (ECMA): Generalize the Caliendo Parro setup to a world with countries, regions within, and forward looking migration
- Eckert 2019 (JMP): Multisector Armington model with Input-output structure across sectors, occupations, skill groups and migration across regions

NON-HOMOTHETIC DEMAND

OVERVIEW

- Moving from CES (or Cobb Douglas) to non-nomothetic presences is appealing for some questions
  - Most salient: richer people spend a smaller fraction of their income on housing
- Several papers introduce non-homothetic preference into the spatial model:
  - Eckert and Peters (2018): “PIGL” preferences from Boppart (ECMA 14)
  - Finlay and Williams (2021): Non-homothetic CES preferences