Are Cities Ever Too Small?

Efficient and Equilibrium Population Levels across Cities

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Introduction: The Economic Purpose of Cities

Are We Over or Under-Urbanized?

Cities define "Civilization" & exhibit increasing returns

- Knowledge spillovers the key to economic growth
- Additional economies from matching and sharing

Negative stereotypes of cities & decreasing returns

- Congestion, pollution, crime, disease
- Common wisdom that free mobility causes over-crowding.
- Federal policies should encourage "population balance."

" Cities can be too large.
Cities can never be too small."

-Arthur O'Sullivan
Urban Economics, 8th edition.

Urban: Corrupt

Rural: Holy

Outline

Analogy of City to a Highway

The Dominant Paradigm for City Size

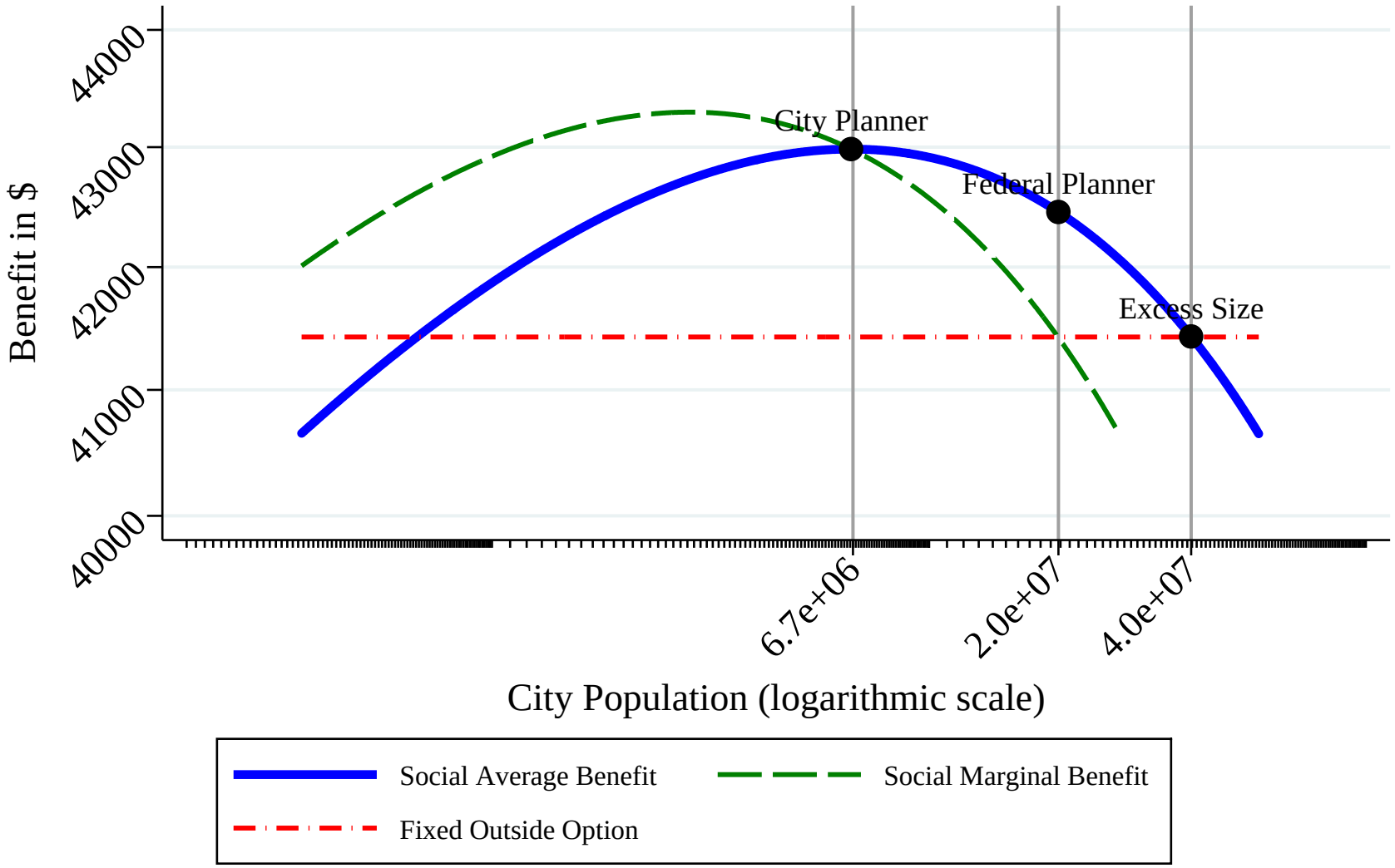
Assumptions

1. Entrant gets (pays) average, not marginal, benefit (cost): external effect internal to road/city.
2. Average benefit curve has inverted-U shape
3. Free access - no toll: population moves to highest benefit
4. Population stable past peak

Conclusions

1. Only stable where marginal below average
2. Equilibrium inefficiently large
3. Tolls or other limits needed for efficiency.

Figure 1S: City Population Concepts for a Single Non-Replicable City



Curves are for values of epilson = 0.06, gamma = 0.30, tau=0.34, delta=0.17, rho=1.00. Productivity calibrated so that gross income, $50000, is 6.667 times average social urban costs. The diseconomy elasticity w.r.t. income is equal to land's share = 0.04. Reference city population = 2000000, Political equilibrium population = 8.6e+05, City planner population = 6.7e+06
Federal tax and land-rent collected and rebated: Reference city = 17592, City planner = 19117, Political equilibrium = 16615

Breakdown of the Highway Analogy

Cities are Different

- Unclear what determines the outside option.
  1. Similar roads/cities: optimum at peak (coordination problem)
  2. A large dirt road/rural life: optimum where marginals cross.
- Sites may differ in quality (productivity, quality of life)
  1. Intensive: Overcrowd better site relative to worse site
  2. Extensive: Occupy only the best sites (Ricardian)
- Welfare effects external to a particular city
  1. Migrants need to buy/rent land - like a toll
  2. Pay federal taxes that vary with wage level
     - Transfers, not social losses
     - Payments greater in larger cities.

Concepts I: Benefit Curves

- Benefit functions/curves a function of city j's population, n
  1. Average vs. Marginal (within-city)
  2. Social vs. Private (across-city)
- Three curves per city, and possibly another.
  1. Social Average Benefit: $SAB_j(n) = SB_j(n)/n$
  2. Social Marginal Benefit: $SMB_j(n)$: social impact
  3. Private Average Benefit: $PAB_j(n)$: actual incentives
  4. *Private Marginal Benefit: $PMB_j(n)$
- Social impact-incentives wedge split within and across cities.

$$SMB_j(n) - PAB_j(n) = \underbrace{SMB_j(n) - SAB_j(n)}_{n\frac{dSAB_j(n)}{dn}} + \underbrace{SAB_j(n) - PAB_j(n)}_{EAB_j(n)}$$

$$= WCW_j(n) + ACW_j(n)$$

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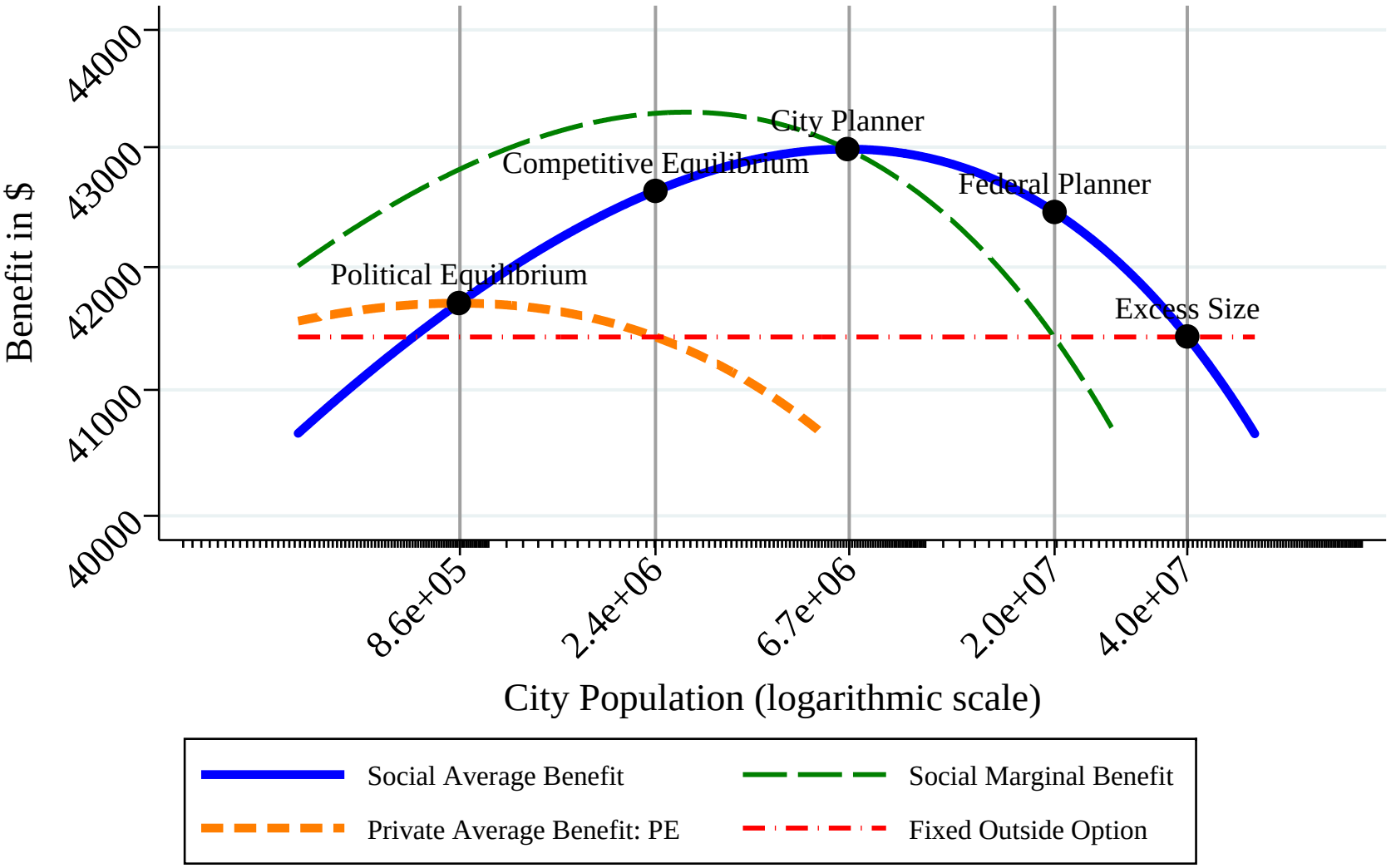

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Concepts II: Solutions

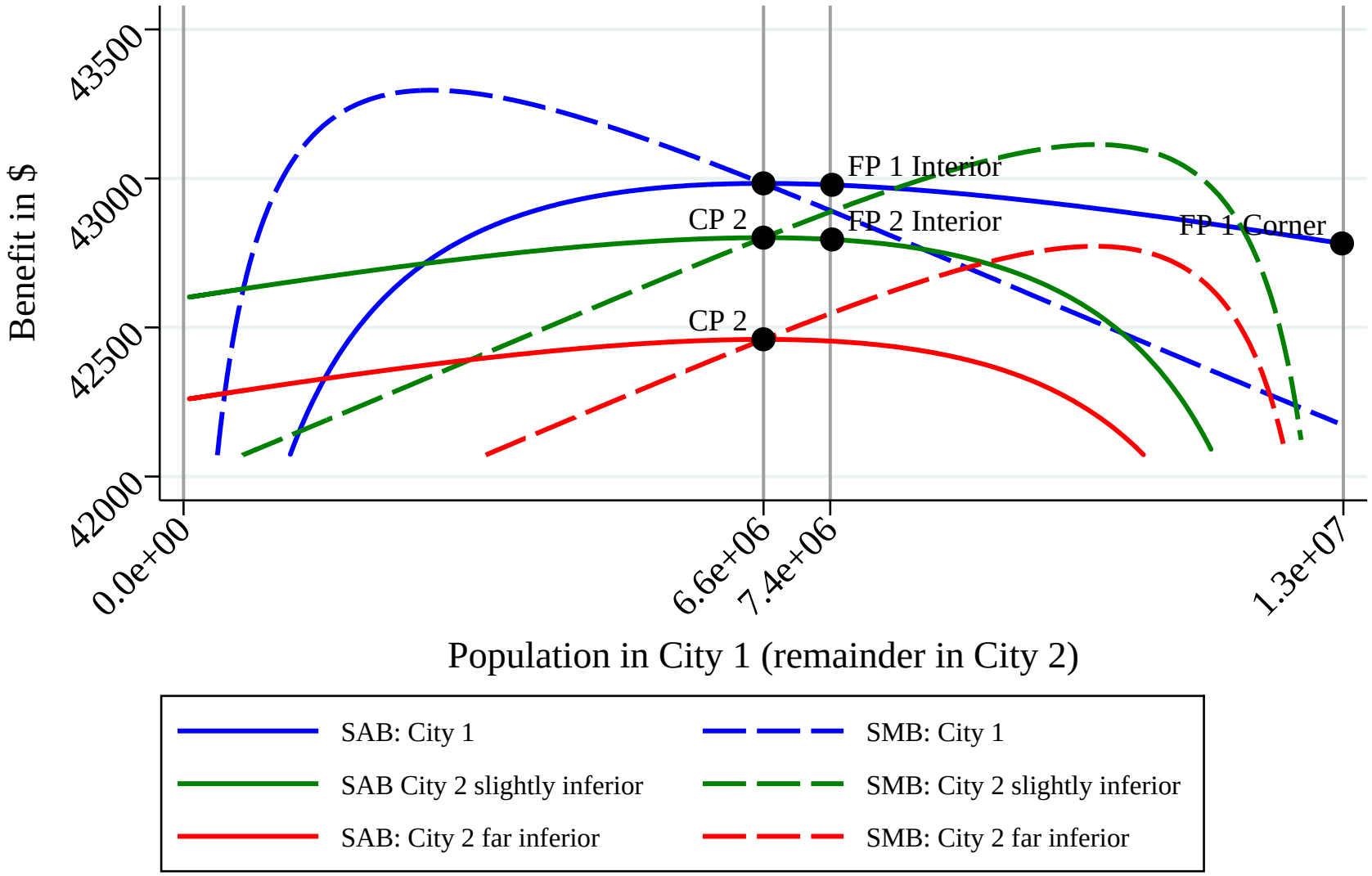
Efficient Solution Concepts

1. "City Planner" (traditional) maximize social average benefit
   - Disregards outside population
   - Assumes site should be developed
2. "Federal Planner" (efficient) equalize social marginal benefit
   - Considers entire population
   - Chooses optimally what sites to develop.

Equilibrium Solution Concepts

1. "Political Equilibrium" maximizes private average benefits
   - Similar to land developer.
2. "Competitive Equilibrium" equalizes private average benefits.
   - Many possible solutions; not clear what we should osberve.

Figure 2: City Population with Two Cities: Interior and Corner Solutions



Curves are for values of epilson = 0.06, gamma = 0.30. Productivity calibrated as in table 1. City 2 has a lower amenity level presenting two possible alternative social average benefits from city 2. The slighly lower Int curve leads to an interior federal planner solution; the much lower Cor curve to a corner. The average welfare gain from city to federal planner is $ 5 in the interior solution, with city 1's population at 7.4e+06, the gain is $ 60 for the corner solution.

Urban Structure and Private-Social Wedges

Land Values, Federal Taxes, and Discounts

Land Values

- Value equal to marginal minus average diseconomy.
- "Shadow profit" from developing a lot with commuting.
- Payment goes to pre-existing land owner.
- May be appropriated locally through property/land taxes

Federal Taxes

- Collected federally and rebated lump sum.
- Reduces incentives to move to high-wage areas.

Discounts on Urban Costs

- Opportunity tax-cost of commuting is an external cost.
- Land payments may be deducted from taxable income.

Literature Review I

Optimal City Size and the Henry George Theorem

Systems of Cities and Optimal Population Distribution

- Optimal Population Policy: Flatters et al. (1974), Boadway & Flatters (1989), Albouy (2012)
  - Equalize net marginal product of labor plus congestion externalities
  - Efficient transfers subsidize externalities, undo taxes, redistribute land wealth.
- Systems of Cities with Pos. & Neg. Returns: Henderson (1985)

Henry George Theorem

- Vickrey (1977) Arnott & Stiglitz (1979), Arnott (2004)
  - Use 100 % land tax to pay for (uncongested) local public good
  - Revenue Exhaustion Theorem: diminishing and increasing returns offset. Constant returns across cities.

Literature Review II

Federal Taxes and Transfers

Equilibrium City Sizes too Large

- Arnott(1979), Abdel-Rahman (1999), Fenge & Meier (2002).
  - Suggest that cities should be constrained or taxed.
- Wildasin (1986): Federal taxes lower value of commute time
  - More commuting: city of fixed population may sprawl
- Kanemoto (1996): Are Japanese cities too big? Inconclusive.

Elements of Our Spatial Model

- Site Heterogeneity: Haurin (1980), Roback (1982)
- Land Ownership: Helpman and Pines (1980)
- Federal Taxation: Hochman and Pines (1993), Albouy (2009)

Amendments for the Developing World

Different Institutional Structures

- Traditional view: cities good for firms; bad for people.
  - Albouy (2008): QOL does not vary with city size.
  - In developing countries? pollution vs. excitement.
- Cross-city externalities may be different
  - Migrants may not pay rents; squatting
  - Income/payroll/sales taxes
  - Formal vs. informal sector: rural areas probably taxed less.
  - Pollution: urban migrants use less land/rain-forest
- Intensive margin may be hard to control.
- Extensive margin may be sensitive to policy
  - Coordination problems may be particularly severe
- Giants from rent-seeking in capitals (Ades and Glaeser, 1995)
- Infrastructure investments and dynamics more difficult.

Lagos

Mumbai

Rio

Shanghai

Brasilia

Tianducheng

Model Specification and Functional Form

Determinants of the Social Benefit

- Fixed population N to split among sites $j \in J$.
- Population of a particular city/site: n

$$SAB(n; a_j, q_j) = a_j n^{\epsilon} - n^{\gamma} + q_j \tag{1}$$

- Per-capita gross output: $a_j n^{\epsilon}$, where $a, \epsilon > 0$
  - agglomeration economies, local public good
  - $\epsilon a_j n^{\epsilon}$ = agglomeration externality
- Per-capital urban cost: n^{γ}, where $\gamma > \epsilon$
  - congestion dis-economies (commuting, DRS in housing)
  - γn^{γ} = dis-economy externality = avg. diff land value
- Fixed amenity value, q_j.
- Per-capital production of numeraire plus amenity value:

$$SMB(n; a_j, q_j) = (1+\epsilon) a_j n^{\epsilon} - (1+\gamma) n^{\gamma} + q_j \tag{2}$$

$$= SAB(n; a, q_j) + \epsilon a_j n^{\epsilon} - \gamma n^{\gamma} \tag{3}$$

City Formation with Local and Federal Policy

Determinants of the Private Benefit.

$$PAB(n; a_j, q_j) = (1-\tau)a_j n^{\epsilon} - (1-\delta)(1+\rho\gamma)n^{\gamma} + q_j \quad (4)$$

τ Federal tax on wages

- Payment $= \tau a_j n^{\epsilon}$ increases with a_j and n

δ Federal discount on urban costs

- Extent that opportunity cost of commuting is taxable labor
- Land costs are often deductible from taxes

ρ Payment to landowners, or taxed and rebated federally

- $1-\rho$ taxed and rebated locally: get average (or developer)
- Land-use within city rationed fully by price efficiently

Monocentric City Microfoundations

- Homogeneous household consume one unit of land; supply one unit of labor.
- Lives in a circle at distance z. Commutes radially to CBD.
- Firms perfectly competitive, have CRS production $a_j^* n_{ij}$
  - Firms spillovers cause $a_j^* = a_j(\sum_i n_{ij})^\epsilon$
  - Workers receive gross wage $w^j = a_j^* = a_j n^\epsilon$
  - Net wage $= (1-\tau)w^j$
- Commuting costs proportional to $\pi^{-\gamma} z^{2\gamma}/(1+\gamma) = n^\gamma$
- Urban cost $= (1+\gamma)n^\gamma =$ commuting $+$ (shadow) land costs
  - Opportunity cost of land is zero. δ affects market value.
  - Market rent at center $r(0) = (1-\delta)n^\gamma =$ max comm. cost
  - External social loss $= \delta n^\gamma =$ opp. cost of commuting.
  - Discount in land rent $\delta\gamma n^\gamma$ a private transfer.
- Local govt. collects $1-\rho$ of land values, rebates back avg.
- Fed govt. collects ρ of land and τ of labor, rebates back avg.

Henry George and the City Planner Optimum

Federal Planner Optimum when all Cities the Same

The Basic Henry George Theorem

$SAB_j(n)$ at peak where $SMB_j(n) = SAB_j(n) \Rightarrow \epsilon a_j n^{\epsilon} = \gamma n^{\gamma}$

- Land income share equals agglom. elasticity. $\epsilon = \gamma n^{\gamma}/(a_j n^{\epsilon})$
- e.g., 100 % local land tax spent on pure local public goods.

City Planner's Optimal Size

$$n_j^{CP} = \left(a_j \frac{\epsilon}{\gamma}\right)^{\theta}, \theta = \frac{1}{\gamma - \epsilon} \tag{5}$$

- Does not depend on q_j; $\theta =$ elasticity of n to productivity a_j.
- Cities homogeneous: optimal number of cities $J = \left\lfloor \frac{N}{n_j^{CP}} \right\rfloor$

The Across-City Wedge and the Political Equilibrium

The Across-City Wedge from Effects External to City

$$SAB_j(n) - PAB_j(n) = \tau a_j n^{\epsilon} + \rho\gamma n^{\gamma} - \delta(1+\rho\gamma)n^{\gamma} \tag{6}$$

- Positive tax and land-value payment fiscal externality
- Negative externality from discount to commuting and land.

Political Equilibrium with Private Incentives — NIMBY

$$n_j^{PE} = \left[\frac{1-\tau}{(1-\delta)(1+\rho\gamma)}\right]^{\theta} \underbrace{\left(a_j \frac{\epsilon}{\gamma}\right)^{\theta}}_{n_j^{CP}} \tag{7}$$

- Lowered by taxes and land payments, raised by discount.
- Land rebate/developers case, $\rho = 0$: $n_j^{CP} = n_j^{PE} \Leftrightarrow \delta = \tau$

Federal Planner Optimum over a System of Cities

Objective, Population, and Non-negativity Constraints

$$\max_{n_j} \int_{(a,q)} n_j SAB(n_j; a, q) dG(a, b)$$
$$s.t.\ N = \int_{(a,q)} n_j dG(a, b),\ \ n_j \geq 0$$

- Discrete or continuous sum; not generally solvable.
- Intensive margin: first-order condition, for some multiplier μ^{FP}

$$n_j > 0 \Rightarrow SMB_j(n) = (1+\epsilon)a_j n^{\epsilon} - (1+\gamma)n^{\gamma} + q_j = \mu^{FP}$$

- Extensive margin: for some values (a_0^{FP}, q_0^{FP}), $n_j > 0$ only if

$$\theta\epsilon(q - q_0^{FP}) + (\epsilon/\gamma)^{\theta\gamma}\left[a^{\theta\gamma} - (a_0^{FP})^{\theta\gamma}\right] \geq 0$$

Competitive Equilibrium across a System

- Equilibrium may be explained through a two-stage game
  1. Forward-looking entrants first seek out best potential sites
  2. Begin to populate existing sites when marginal site too low.
- Unique solution, choosiing "best" privately optimal sites.
- Land developers a special case when $\rho = 0$.
- Intensive margin: for some constant, c,

$$n_j > 0 \Rightarrow PAB_j(n) = (1-\tau)a_j n^{\epsilon} - (1-\delta)(1+\rho\gamma)n^{\gamma} + q_j = c$$

- Extensive margin: for some values (a_0^{CE}, q_0^{CE}), $n_j > 0$ only if

$$\theta\epsilon\left[(1-\delta)(1+\rho\gamma)\right]^{\theta\epsilon}(q - q_0^{CE}) + \left[(1-\tau)\epsilon/\gamma\right]^{\theta\gamma}\left[a^{\theta\gamma} - (a_0^{CE})^{\theta\gamma}\right] \geq$$

- Stability: may hold for any population levels $n \geq n_j^{PE}$

Distribution of Population across Sites

The Supramarginal (Worst-Inhabited) City

- Population level in the most inferior city (a_0, b_0) at its peak
  - Federal Planner: at city-planner optimum $n_0 = n_0^{CP} = (a_0\epsilon/\gamma)^\theta$
  - Competitive Equilibrium: at least political equilib. $n_0 \geq n_0^{PE}$

Population Size of Inframarginal Cities

- Population levels rise with levels of a, q. Let $\hat{n} = dn/n$

$$\hat{n}^{FP} = \frac{(1+\epsilon)n^\epsilon da + db}{(1+\gamma)\gamma n^\gamma - (1+\epsilon)\epsilon a n^\epsilon}$$

$$\hat{n}^{CE} = \frac{(1-\tau)n^\epsilon da + db}{(1-\delta)(1+\rho\gamma)\gamma n^\gamma - (1-\tau)\epsilon a n^\epsilon}$$

Optimal Federal Policies

Taking ρ as given τ, δ and setting optimally.

Two policy instruments: Federal tax and discount

$$\tau^{**} = -\epsilon \text{ and } \delta^{**} = -\frac{(1-\rho)\gamma}{1+\rho\gamma}$$

- Pigouvian subsidy $-\tau$ for agglomeration externality
- Congestion charge $-\delta$ for commuting and unpaid land.
  - Not necessary if $\rho = 1$; replace charge with federal land tax.

One policy instrument: federal taxes or discount

- Corrects only for productivity a_j differences.

$$\tau^* = 1 - \frac{1+\rho\gamma}{1+\gamma}(1+\epsilon)(1-\delta), \text{ or } \delta^* = 1 - \frac{1+\gamma}{1+\rho\gamma}\frac{1-\tau}{1+\epsilon}$$

The Henry George Theorem Revisited

Old version: Local land tax: $\rho = 0$.

- Works if $\tau = \delta$ and cities homogenous.
- Breaks down if cities heterogeneous or $\tau \neq \delta$.
- With δ can lead to too much congestion

Revised: federal land tax : $\rho = 1$

- Tax land at 100 % and subsidize agglomeration at ϵ %
  - Echoes Albouy's (2012) result for federal transfers.
  - Henry George against taxing labor; for a subsidy?
- At federal optimum, there should be a surplus!
  - Land values $\geq$ agglom. externaltiy
  - City system exhibits DRS as people added
  - Could pay for federal public goods (country as a city)

Population Distortions relative to Federal Planner

Consider typical case

Political Equilibrium

- All cities too small, even with τ^{**} and δ^{**},
- Smallest city needs to be $\left(\frac{1+\gamma}{1+\epsilon}\right)^{\theta}$ larger.
- Private developers could solve coordination problem with $\tau = \rho = \delta = 0$

Competitive Equilibrium

- Smallest cities may be as low as political equilibrium n_0^{PE}
  - Extensive margin biased towards QOL, away from productivity.
- Population increase with productivity too low
  - Productive cities are likely too small.
- Population increase with quality-of-life probably not too high
  - Lots of small, low productivity cities with decent QOL.
  - Highest QOL cities may be under-populated.

Calibration

Base parameters

Agglomeration $\epsilon = 0.06$ elasticity of wages w.r.t. pop. 0.03-0.08.

Diseconomy $\gamma = 0.30$ Between land and commuting elasticity

Tax $\tau = 0.34$ Fed. inc. + payroll; state inc. + sales.

Discount $\delta = 0.17 = \tau/2$ Time-cost & housing benefits

Land payment $\rho = 1$ Most realistic for new migrants.

Other values parameters

Population $n = 2,000,000$ typical metro size

Output-to-Urban Costs 6.667 Income vs. commuting cost.

Household income \$ 50,000

Figure 3: Coordination Problem with Homogenous City Sites

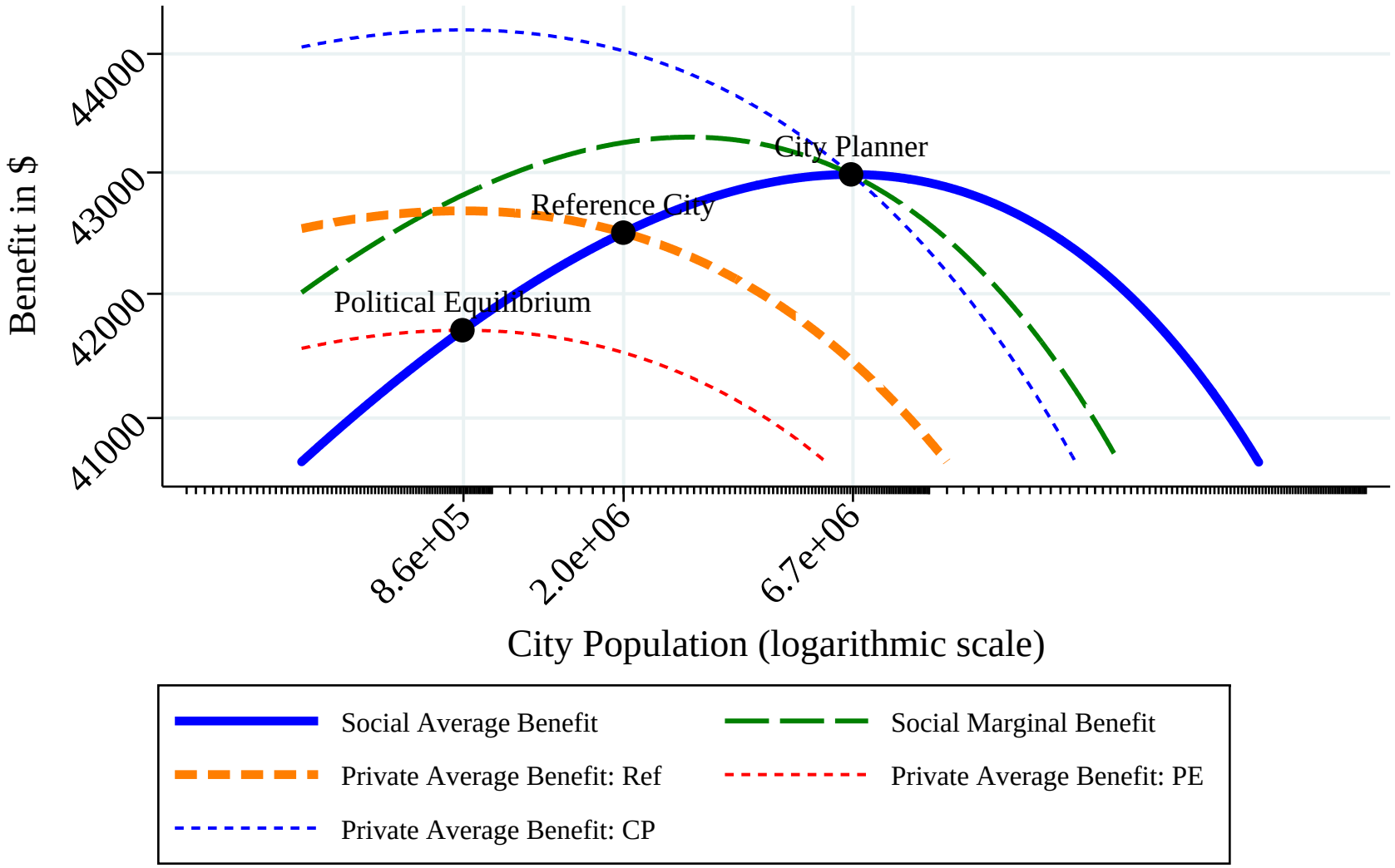


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Figure 4: City vs. Federal Planner for Cities Varying in Productivity

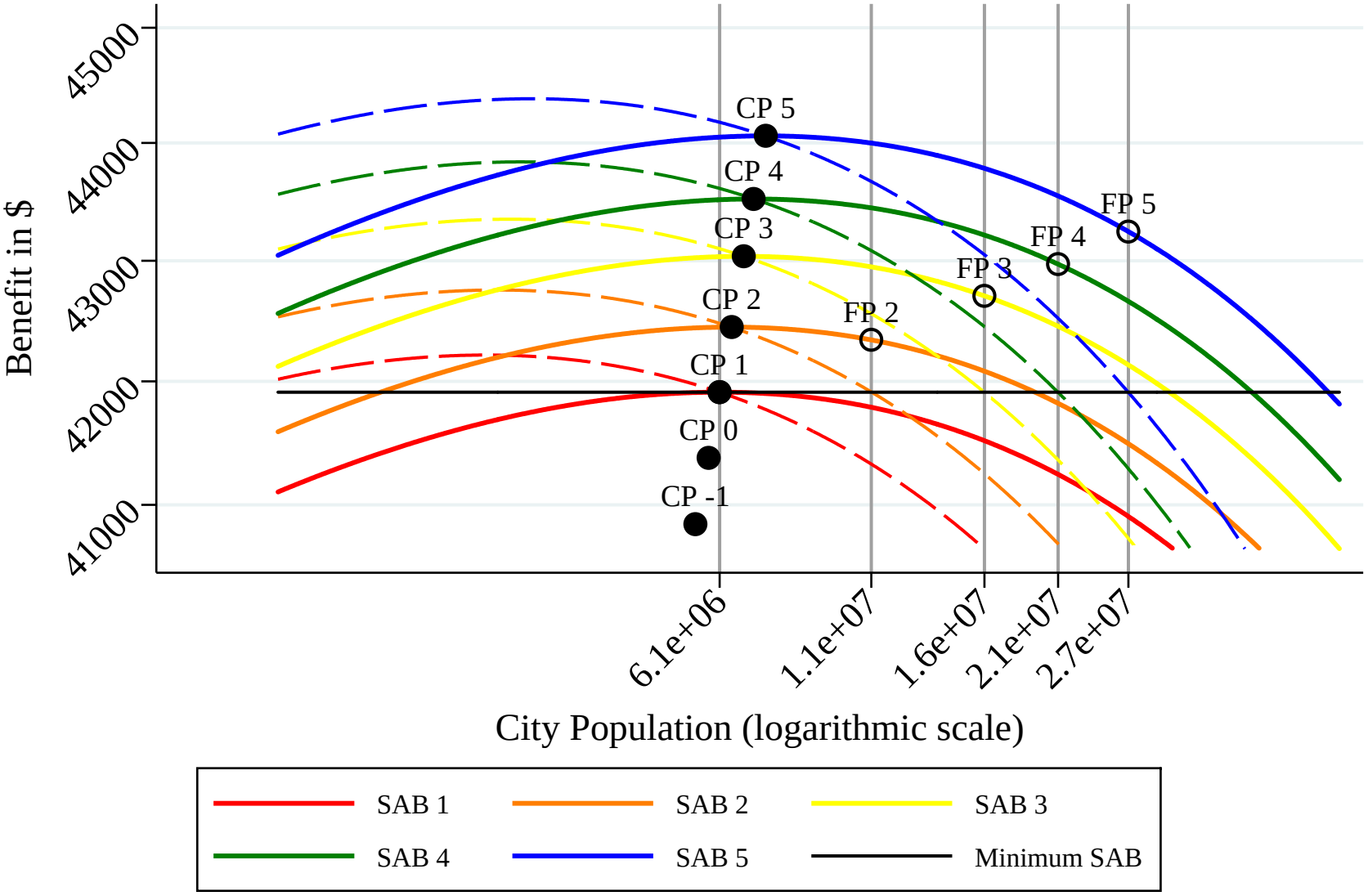

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Figure 5: Political and Competitive Equilibira for Cities Varying in Productivity

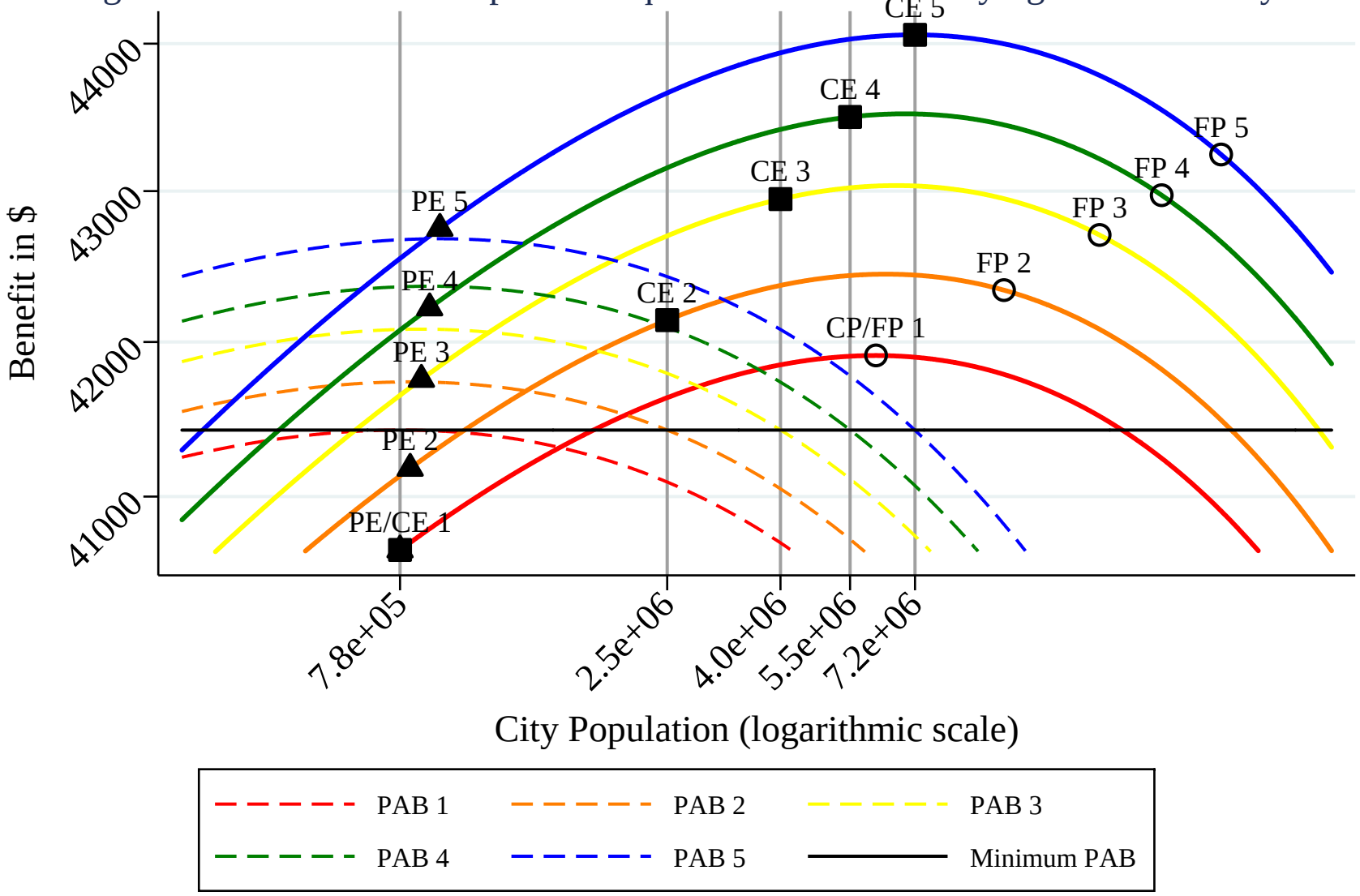

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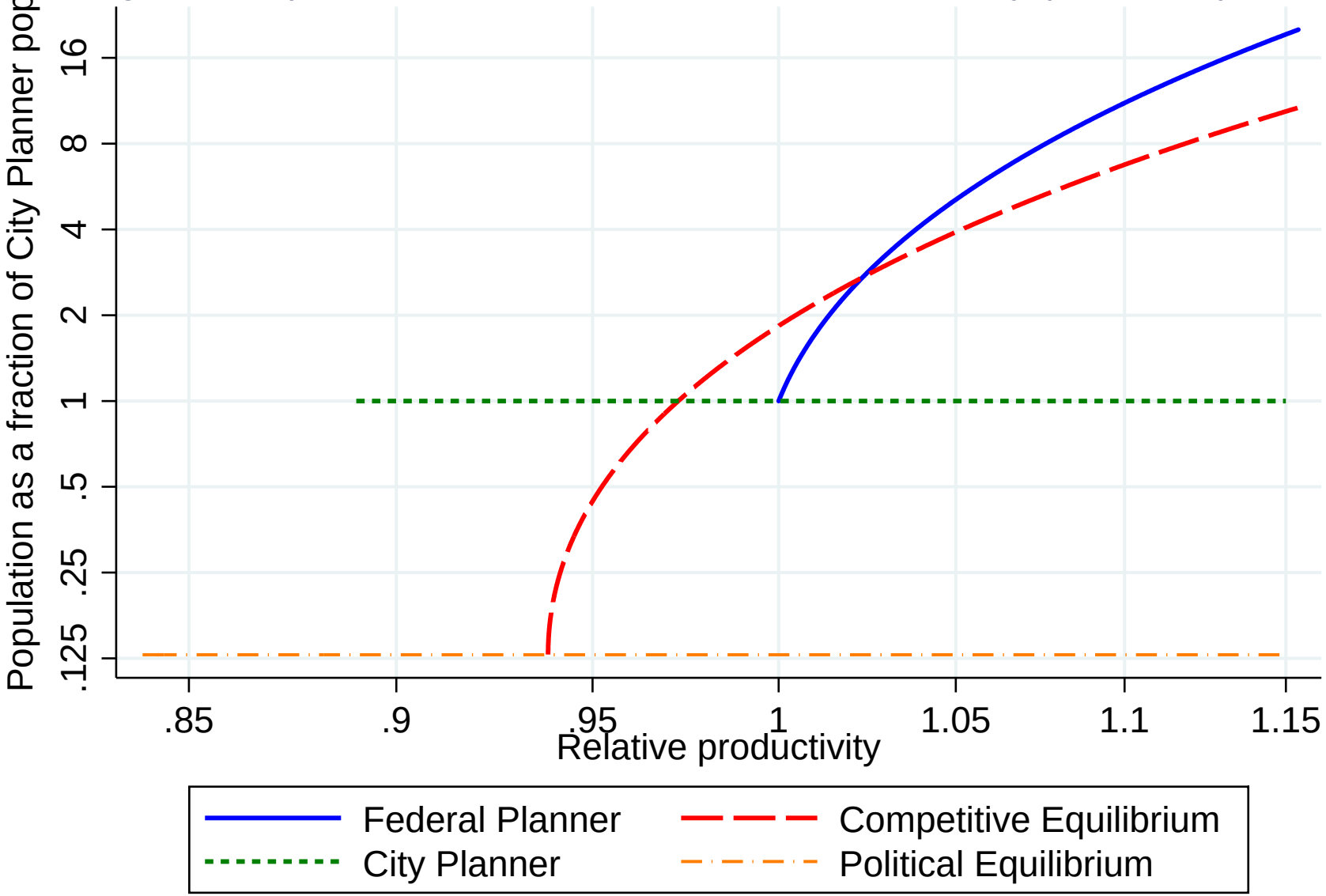
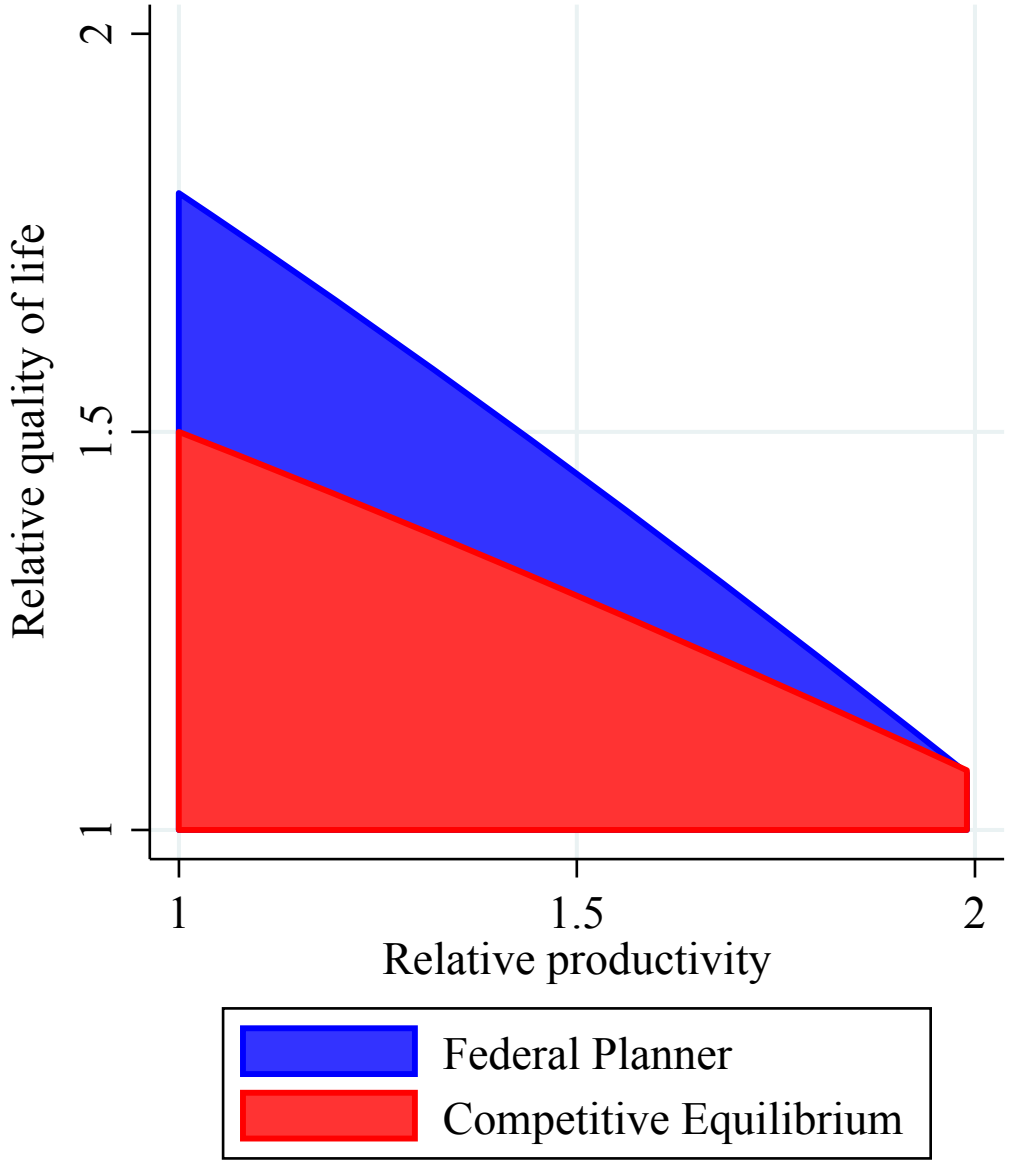
Figure 6: Population as a Function of Relative Productivity (Illustration)



Curves are for values of epilson = 0.06, gamma = 0.30, tau=0.34, delta=0.17, rho=1.00.

Figure 7: Extensive Margin of Sites Not Built On



Simulations

Homogenous-site: Optimal vs. Equilibrium

- Reference city of 2 million appears above political equilibrium
  - Cannot be below in a valid calibration!
- Observed pop below city planner for plausible parameters.
  - Welfare difference between CP/FP and PE = 3 % of income.

Heterogeneous-site: Optimal vs. Equilibrium

- FP pop. much more responsive to productivity than CP.
- CE smaller than FP & usu. CP. Much bigger than CE.
- Smaller cities means lower site quality
  - Extensive margin CE bias: QOL okay, productivity low.
- In equilibrium cities are probably too small!

Conclusions

- Cities can be too small (or too big)
  - Must consider welfare of the entire population
  - Some sites may be better to abandon.
- Site heterogeneity and across-city externalities important
  - Free-mobility equilibrium under-populates productive areas.
  - High quality-of-life cities less certain.
  - NIMBY Local politics may lead to best sites vastly undersized.
- Henry George Theorem generalized to heterogeneous cities
  - Federal land tax = 100 % + big-city work subsidy + surplus!
  - Subsidy to wage + congestion charge may also work.
- Model still very limited: room for further research.