Monocentric City with Heterogenous Groups; Discussion of LeRoy and Sonstelie

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Paper Overview: Class Discussion

1. What is the main question of this model? What are they trying to explain?
2. What is the primary result? What is the intuition for this result?
3. How is the model set up? What are the main variables?

Paper Overview

Paper tries to explain how commuting costs can affect location choices of rich and poor

Shows that changes in fixed and variable costs of commuting, relative to wages, can lead to different location patterns by income

Main intuition:

- when faster commuting technology is very expensive for poor than rich will locate in suburbs to take advantage of cheaper housing
- when poor are able to afford this technology they also wish to live in suburbs, bidding up suburban house prices, making central city locations more attractive to rich

Argues that these predictions are consistent with location patterns of rich and poor over a period of US history with significant innovation in transportation

Commuting Modes

Two commuting modes m: automobile a and bus b, $m \in \{a, b\}$

Each commuting mode has a i) fixed cost (f^m) ii) variable cost in distance ($c^m/2$) iii) time cost, measured in lost wages

Speed for each mode is 2 miles in t^m hours, which implies $2 * (1/t^m)$ miles per hour

Daily commute is $2 * d$ (back and forth at dist d to CBD), thus with wage w time cost is: $w * d * t^m$

Commuting cost: $f^m + c^m * d + w * d * t^m$

We assume cars are more costly in both fixed and variable costs, $f^a > f^b$, $c^a > c^b$, but are faster $t^a < t^b$

Commuting Mode Choice by Distance

When wages are "high enough" there will be a distance d^* where the cost of commuting by car is equal to that of the bus

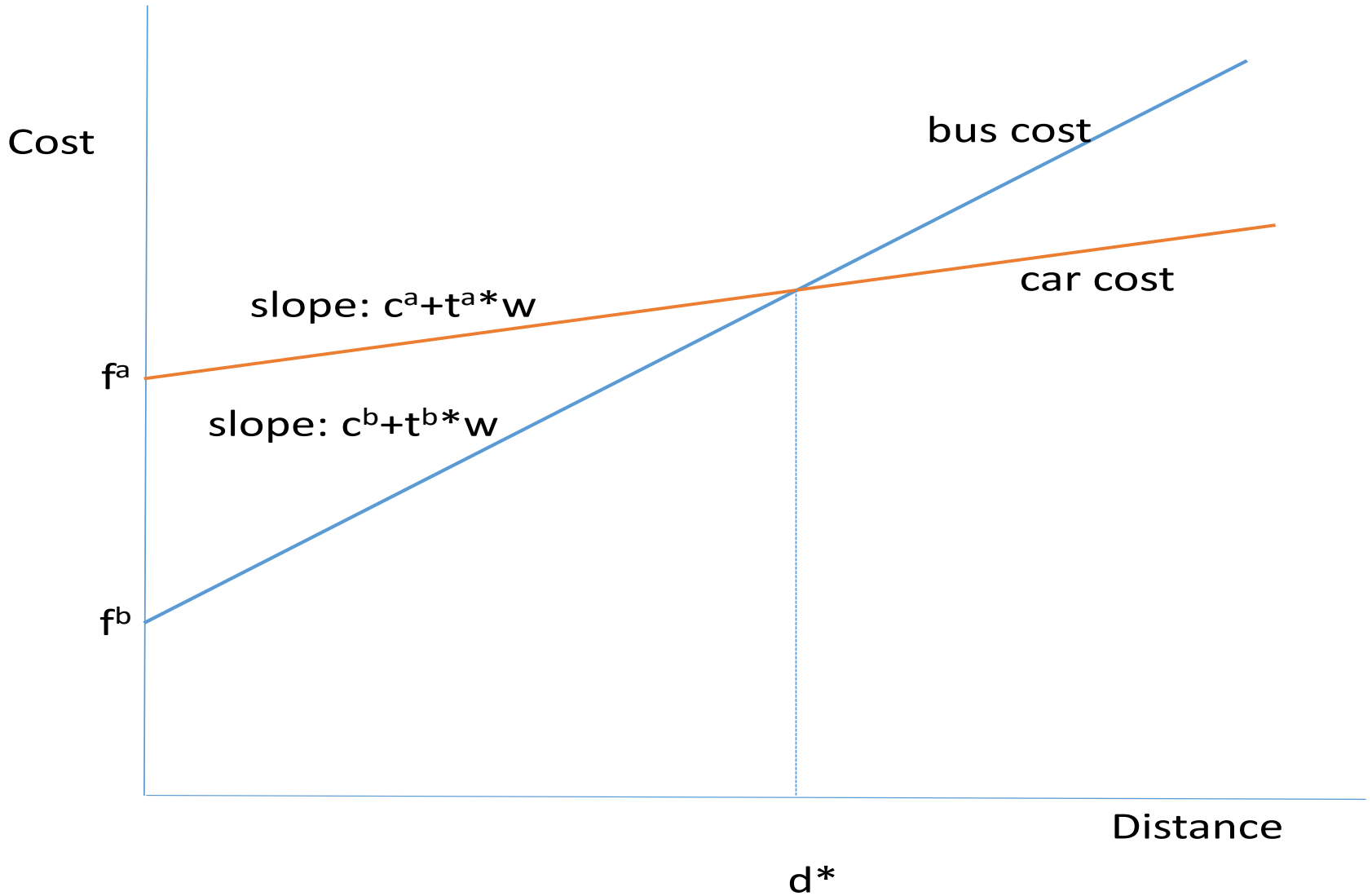
This is because a high wage makes the marginal cost of commuting (wrt distance) higher for buses than for cars: $c^a - w * t^a < c^b - w * t^b$

$$d* = \frac{f^a - f^b}{c^b + w * t^b - c^a - w * t^a} \tag{1}$$

Note: this distance d^* could be beyond the city limits for low wages

Easiest to see this in a graph

Commuting Cost by Distance



Bid Rent by Commuting Mode

Consumers have utility over housing and numeraire $U(h, x)$

Budget constraint for mode m:
$x + r(d) * h + f^m + c^m * d + w * d * t^m = w$

Bid rent is max r subject to $U(h, x) = \bar{u}$:

$$r^m(d; u, w) \equiv \max_{h,x} \left(\frac{w - f^m - c^m * d - w * t * d^m - x}{h} \right) \quad (2)$$

This gives gradient (envelope theorem) as

$$\frac{\partial r^m(d; u, w)}{\partial d} = -\frac{c^m + w * t^m}{h} \quad (3)$$

This Alonso-Muth condition replaces τ with marginal commuting cost

Bid Rent by Distance

The bid-rent is then the envelope of the commuting mode bid-rent curves: whichever is higher at distance d is the bid-rent curve

We know that costs of two commuting modes intersect at d^* and thus bid-rent must also intersect at this point

Note: housing is not a function of commute mode (parking might complicate this)

Commuting Cost by Distance

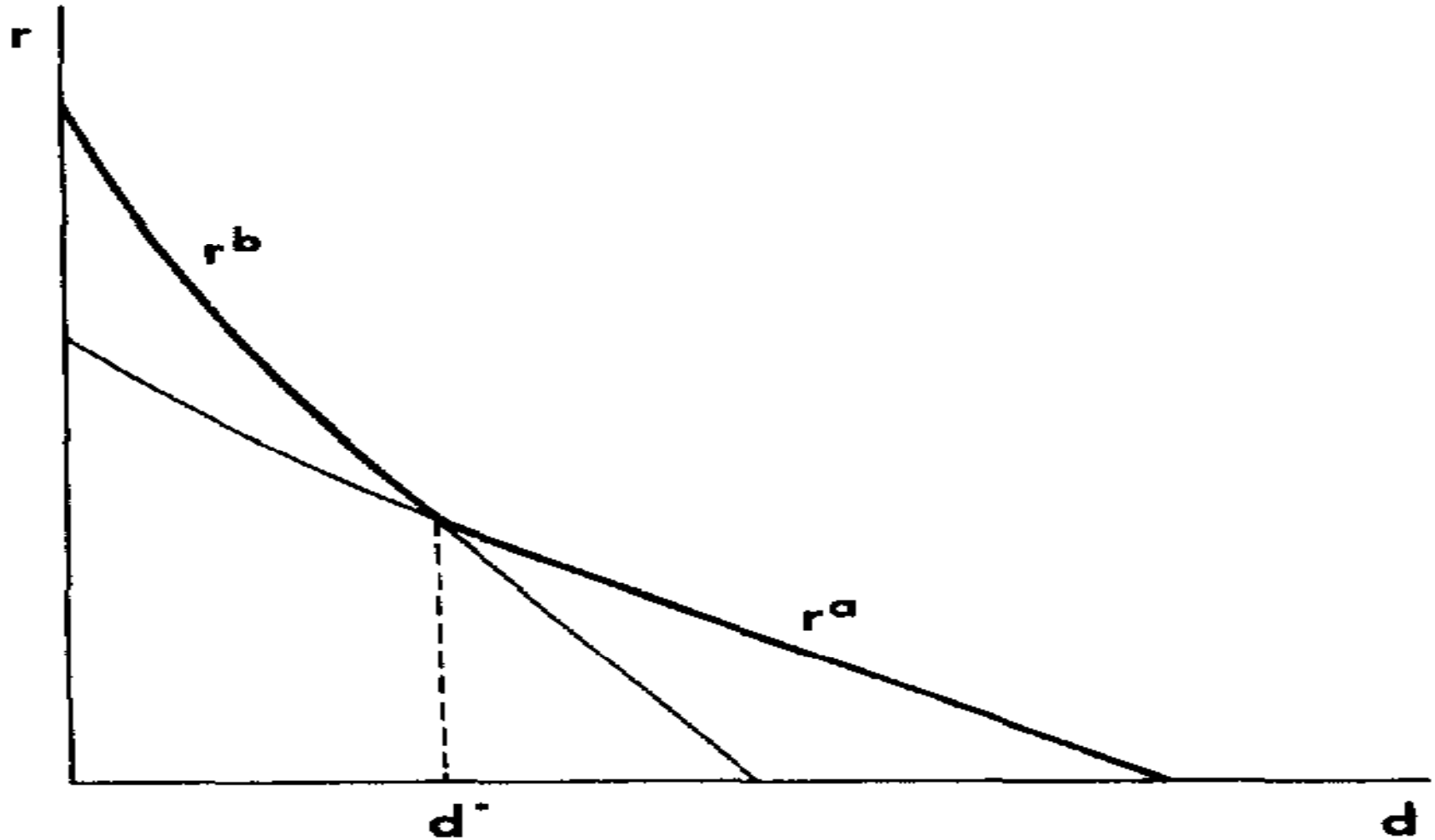


FIG. 1. The bid-rent function.

Who Lives Where?

We now want to figure where the rich (w_r) and poor (w_p) live in the city

All individuals in a group must have the same utility; rich utility should be higher than poor utility

The group with the highest bid-rent for each location lives in that spot

Question: if the rich have more income, how can the poor have a higher bid-rent curve at some locations?

When two bid rent curves intersect at distance d, the group with the steeper bid rent gradient must live on the side closer to the CBD

We first examine the simple case of zero fixed costs in commuting–why is this simpler?

Zero Fixed Cost

With zero fixed costs the commuting cost of one mode is always higher than the other, for each group (the cost lines never intersect or $d^* = 0$)

This means that each group will only use one commuting mode at all distances

Say c^a is so high that both groups commute by bus b, $c^a + t^a * w_r > c^b + t^b * w_r$, who will live where?

Turns out it depends on whether the effect of income on housing demand is greater than the effect of income on marginal commuting costs:

Do the rich live in the center because their time is so valuable or do they live in the suburbs because they have high housing demand?

Commuting and Housing Income Elasticities

When both commute by bus, the poor will live closer to the CBD if their bid-rent curve is steeper at the intersection with bid-rent curve of rich:

$$\frac{c_p + w_p * t_p}{h_p} > \frac{c_r + w_r * t_r}{h_r} \tag{7}$$

Define $M_g \equiv c_g + w_g * t_g$ and then let η_c and η_h be the *arc* elasticities of commuting cost and housing wrt income:

$$\eta_c = \frac{\frac{M_r - M_p}{M_p}}{\frac{w_r - w_p}{w_p}} \text{ and } \eta_h = \frac{\frac{h_r - h_p}{h_p}}{\frac{w_r - w_p}{w_p}}$$

Then if $\eta_h > \eta_c$ the rich live in the suburbs and the poor closer to the CBD; we often assume $\eta_c > \eta_h$ (as does this paper)

Notice that $\eta_c \approx 1$ when $c_p = c_r$ and c_p is small

Three Eras

"Paradise Lost" and "Paradise Regained" are famous poems by John Milton (17th century England); authors use these to describe location patterns

1. Paradise: cars are very expensive, both groups use bus, rich live in center
2. Paradise Lost: variable cost of auto drops enough relative to wages that rich can afford cars but poor cannot; rich live in suburbs, poor in center
3. Paradise Regained: variable cost of auto drops so much both groups can afford cars; rich again live in center, poor in suburbs

Paradise and Paradise Regained

Paradise

- if both groups use bus then we already know location pattern depends on η_c vs η_h
- Author argues that variable commuting cost of bus c^b is low and thus $\eta_c \approx 1$. Empirical evidence argues for $\eta_h < 1$ and thus if both groups commute by bus the rich live in center.

Paradise Regained

- authors make same argument that when c^a has fallen sufficiently so that both groups can afford cars then $\eta_c > \eta_h$

Most interesting case is Paradise Lost: why do rich live in suburbs when poor can't afford cars but then in center when the poor also drive (Paradise Regained)?

Paradise Lost

Variable commuting cost c^a is such that the rich drive, poor take bus

Question is how gradients compare at intersection point:

$$\frac{c_b + w_p * t_b}{h_p} > \frac{c_a + w_r * t_a}{h_r} \quad \text{(PL)}$$

Since $c_a > c_b$, $w_r > w_p$, and $t_a < t_b$, it's possible that marginal commuting costs are lower for the rich, or that housing demand h_r is large enough to make PL true

Notice that when the rich live in the suburbs they will enjoy low housing prices because there is no competition for space from the poor, who cannot drive

Positive Fixed Costs Equilibrium

With positive fixed costs we can have equilibria where both groups use both commuting modes if fixed and variable commuting costs are low enough

Then each group will have a separate distance where commuting by car becomes cheaper, d_r^* and d_p^*

For $d < d_r^*$, rich and poor use buses, for $d^* r < d$ the rich drive but the poor still take the bus

This is the Paradise case where rich live in the center

Paradise with Fixed Costs

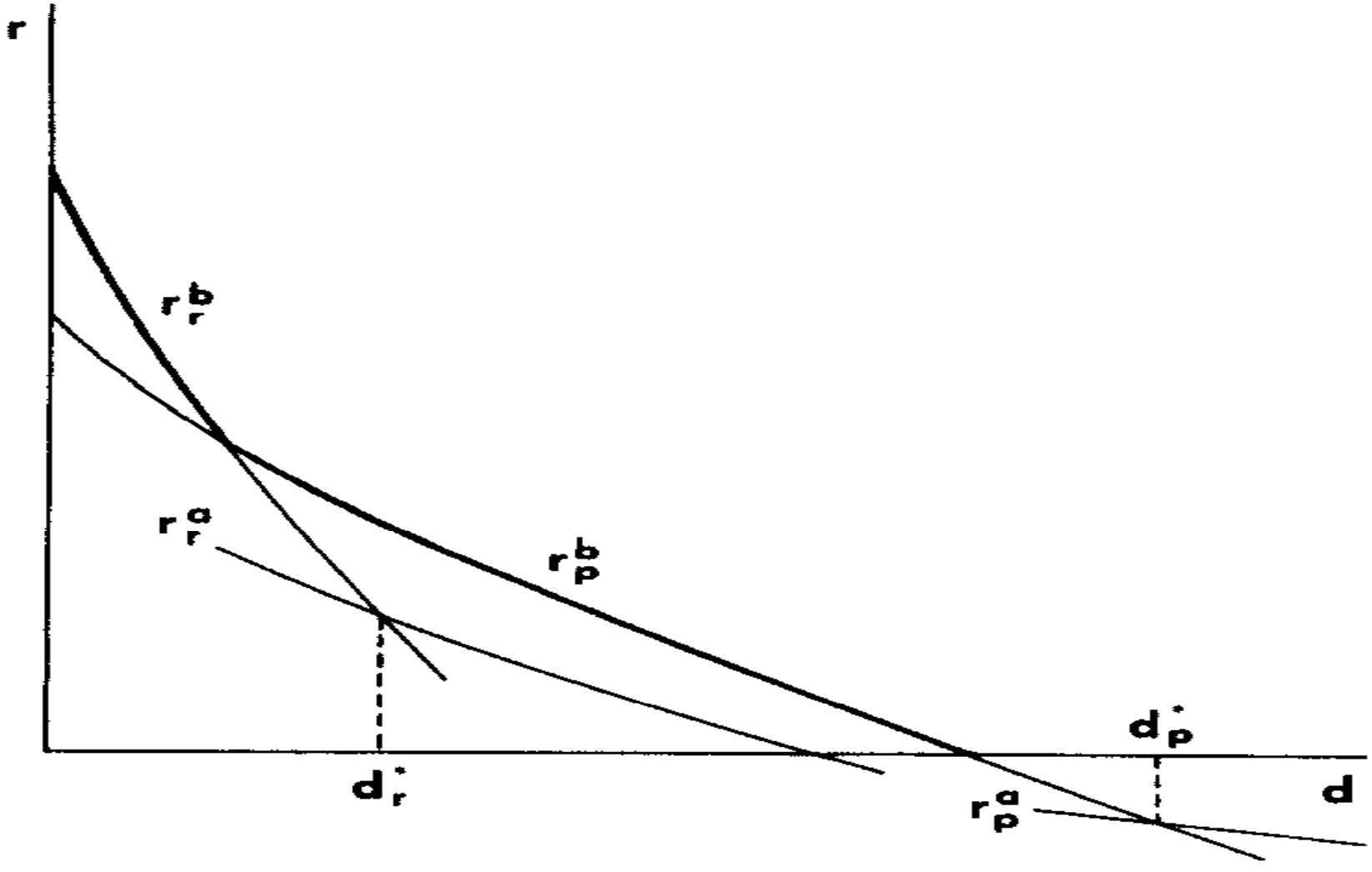


FIG. 2. Paradise.

Paradise Lost with Fixed Costs

As f^a and c^a drop further the d^* points shift closer to the CBD, decreasing the area where the rich would want to live in the center and take the bus

Some rich will now decide to live in suburbs and drive

As costs continue to decline all of the rich may then move to the suburbs (Paradise Lost)

Paradise Lost with Fixed Costs

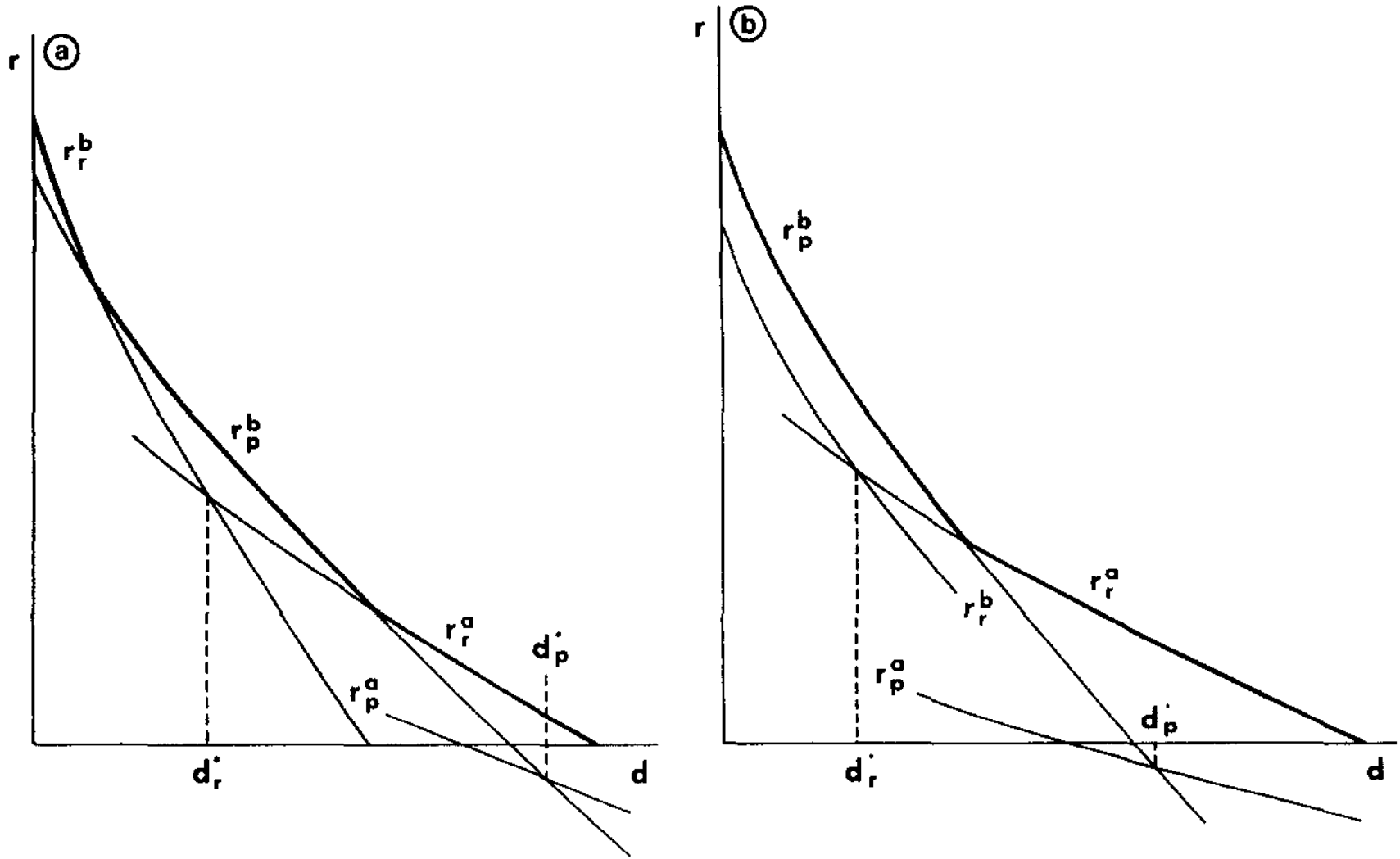


FIG. 3. Paradise lost.

Paradise Regained

Now as f^a and c^a drop further the poor also drive in the suburbs, putting pressure on suburban housing prices

This pressure causes some rich to move back to the center but some rich also stay in the suburbs

This creates four zones: rich bus, poor bus, rich auto, poor auto; the authors call this regentrifiction

Finally, costs fall enough that we get the Paradise Regained equilibrium with rich in the center (both bus and auto) and poor in the suburbs

Note: authors show case where poor only drive in suburbs but an equilibrium where they also use the bus (and then car) might be possible depending upon population sizes

Regentrification

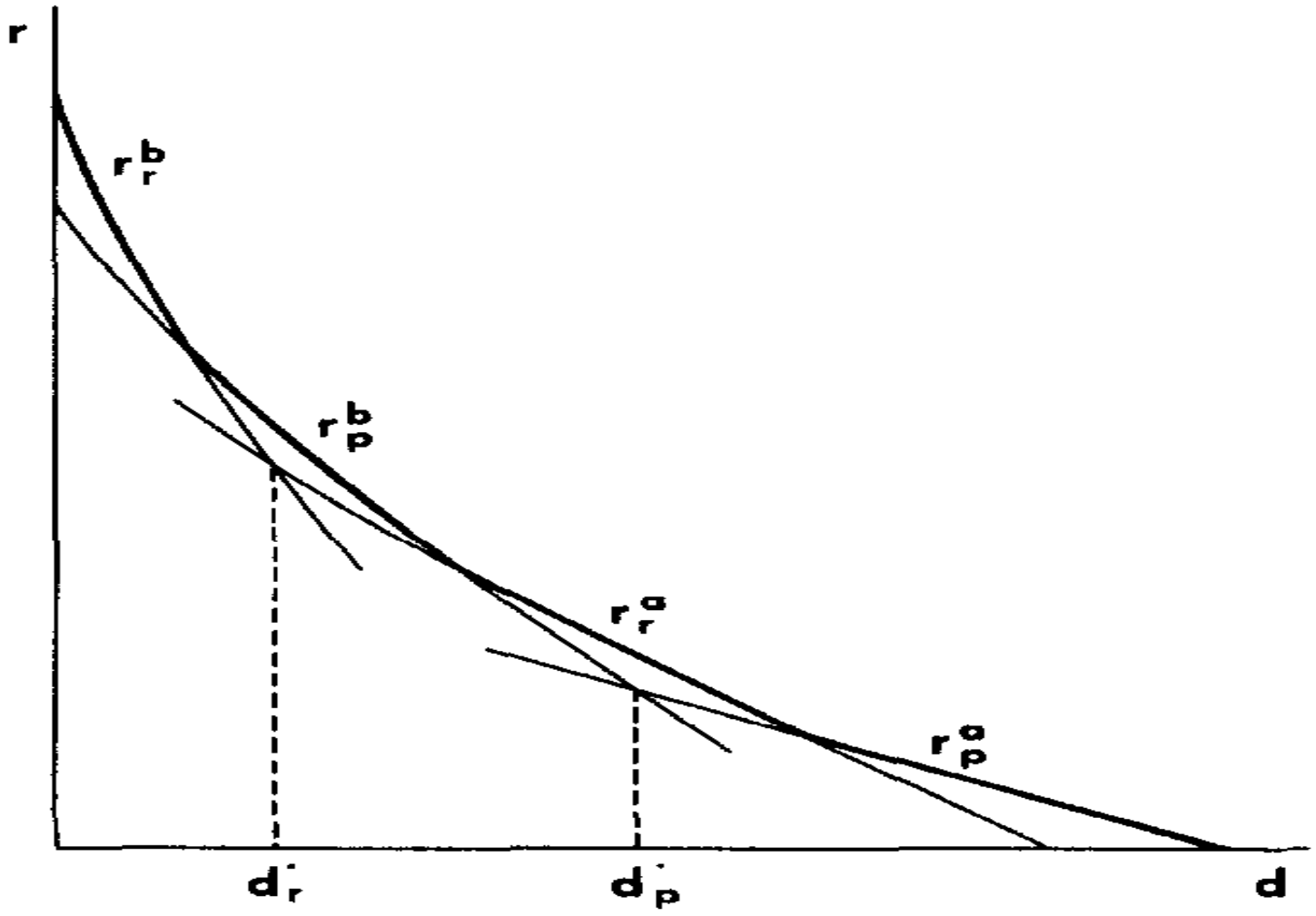


FIG. 4. Regentrification.

Paradise Regained with Fixed Costs

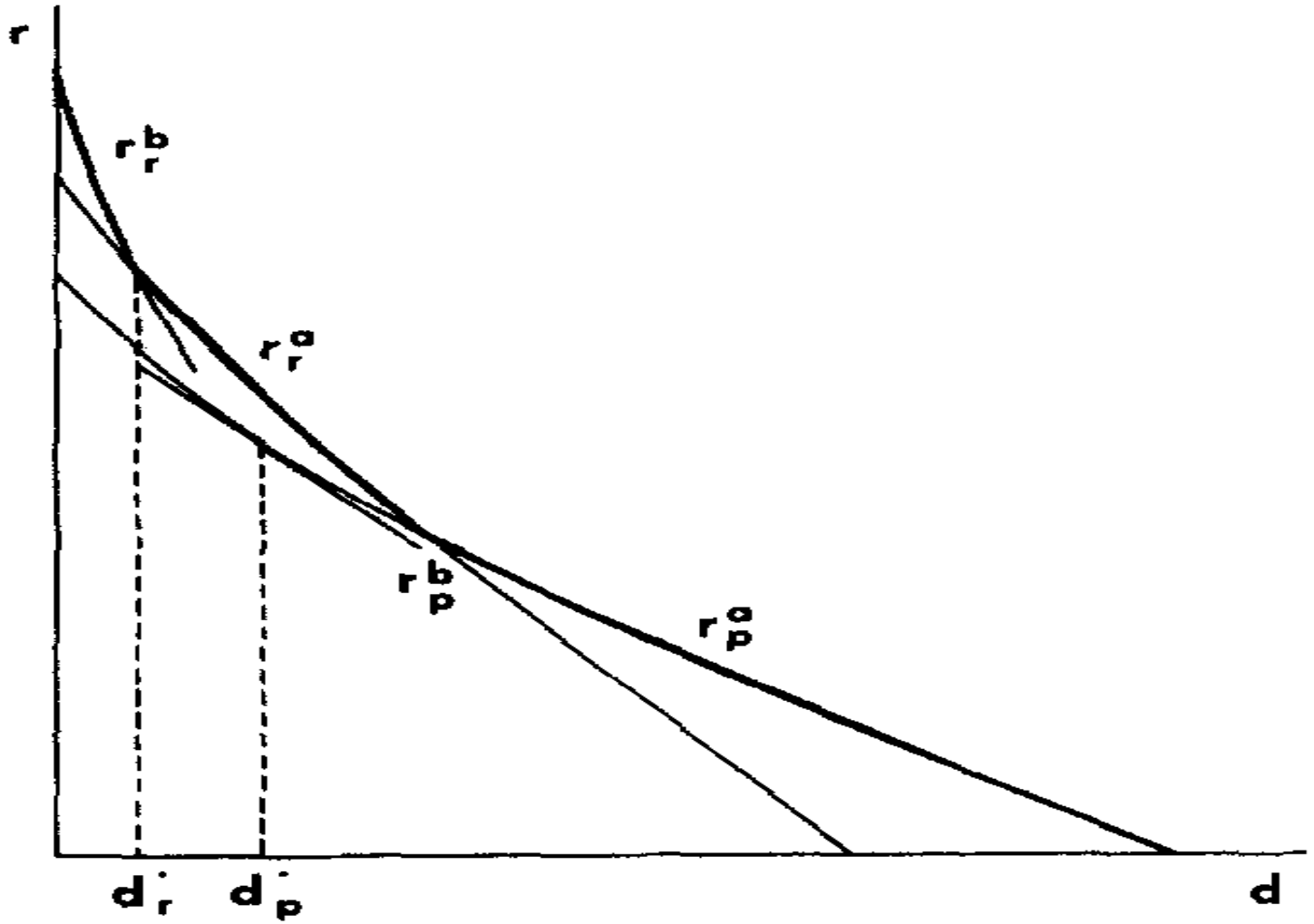


FIG. 5. Paradise regained.

Evidence from US Transport History

1. In 18th and 1st half of 19th century everyone walks so rich live in center (Paradise)
2. From 1830-1850 the “omnibus” and commuter rail started being used but commuting was only affordable for very rich; some very rich use these and move into suburbs (Paradise Lost)
3. Next, in 1850’s and 1860’s streetcar is introduced; commuting by street car is expensive but affordable for professional workers, wealthy suburbs grow in size (more Paradise Lost)
4. Streetcar gets cheaper and cheaper but before Paradise Regained occurs the car is invented. This new technology is faster but expensive, thus rich continue to live in suburbs (and middle class or poor can take street car)
5. Finally, authors argue that in 1980’s as cars become cheaper there is evidence of rich moving back to cities

Application to Contemporary China?

I think there is potential to extend this analysis to China; there seems to be little work (at least in English) in this area

What should be the effect of expensive license plates in cities like Beijing and Shanghai?

What about extensions of subway lines? High speed rail?

Could car-sharing services (Uber, Didi) have an effect?

What do we know about location patterns of rich and poor in China? What data can we use?

Monocentric City Model: Criticisms

Elegant analytical framework has a cost: some unrealistic and non-trivial assumptions

1. Everyone commutes to job in CBD; many cities are polycentric (multiple job centers)
2. Housing stock is perfectly flexible; in fact, housing stock is quite durable and this durability is important
3. No zoning or regulations; empirical work argues these frictions can be significant
4. Residents are identical; this is relaxed somewhat with different types (like today) and even more by assignment models (see discussion in Duranton and Puga 2015 RUE Handbook)

Nonetheless, a very important and flexible model, continues to be widely used

Monocentric City Model: Extensions

Many extensions, summarized in Duranton and Puga 2015:

1. Commuting costs: can add leisure to utility function and make labor hours endogenous; can allow more commuting options and methods (ex: radial highways)
2. Heterogeneity in residents and land use
3. Durable housing or endogenous development decisions
4. Polycentricity: several famous papers on this (Fujita and Ogawa, Lucas and Rossi-Hansberg), fairly difficult models

Monocentric City Model in China

1. Zheng, Siqi and Kahn, Matthew "Land and residential property markets in a booming economy: New evidence from China," *Journal of Urban Economics*, 2008.
2. Deng, Huang, Rozelle, Uchida, "Growth, population and industrialization, and urban land expansion of China," *Journal of Urban Economics*, 2008.
3. Ke, Shanzi, Song, Yan, and He, Ming "Determinants of Urban Spatial Scale: Chinese Cities in Transition," *Urban Studies*, 2007.