

Forecasting Population with Urban Economics: The SAM Houston model for Harris and Galveston Counties

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Objective

- Develop a Long Run Forecasting Model that allocates population across the metro area- out to the year 2100!
- To do so, we use urban economics theory to understand how population is distributed.
- The theory we use is based on employment
 - Maybe Houston specific- we are here in Houston because of work, not great weather and beautiful mountains!

Our Forecast Depends on Census Data: Using Census Tracts as the Unit of Geography

- Census Blocks only to convert between years
- One interesting fact: The ACS is supposed to be improved, and be useful at the tract level
- We did some general analysis of the ACS data, and it looked pretty good initially. We used ACS 2019 to assess our 2010 forecasts
- When the 2020 Census data came out, my assistant said to me: “Boy, your 2010 forecasts look a lot better!”
- The ACS has not been good on migration, and apparently it still is not-
 - Although the census tract allocations of their bad forecasts seems decent

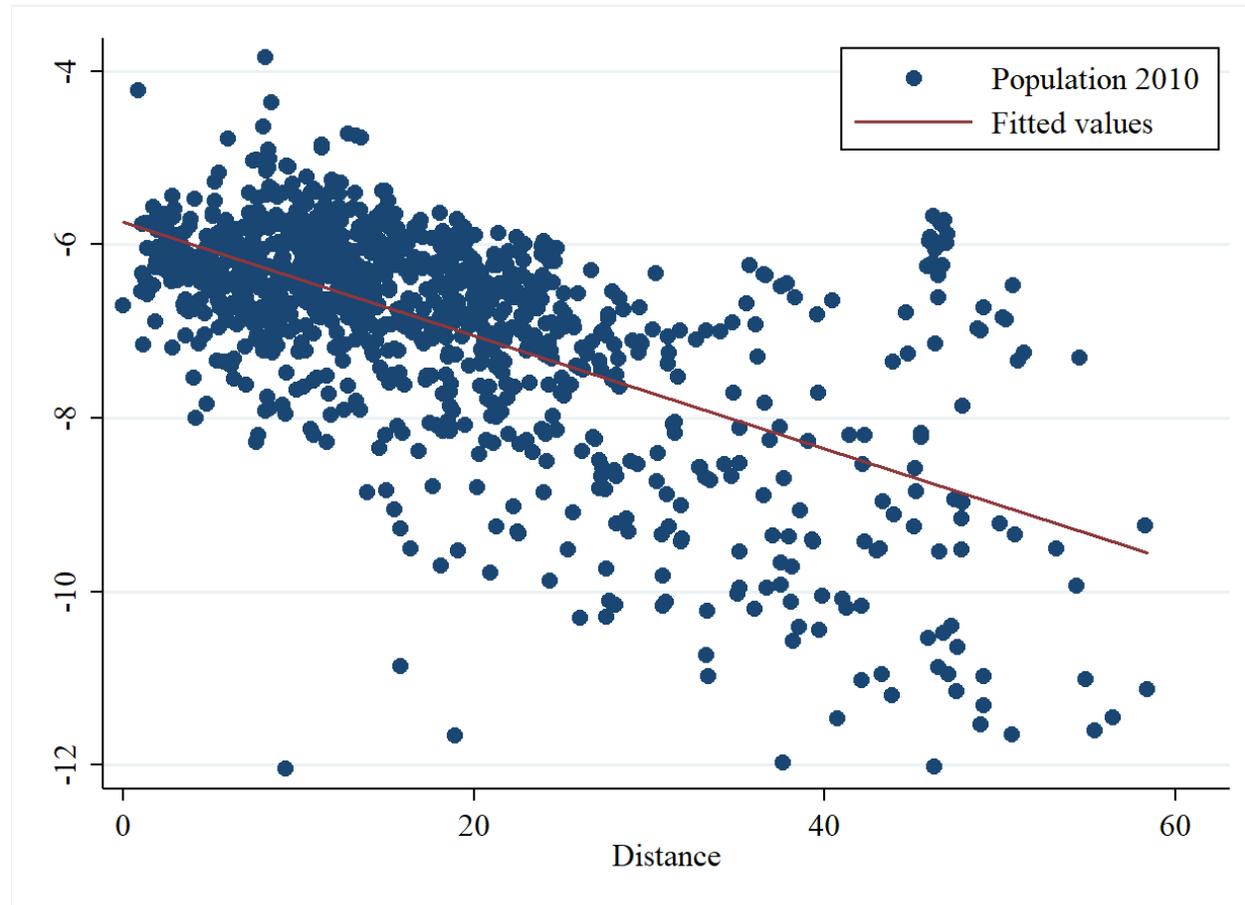
Urban Economics: How Employment Shapes a City—Especially Ours

- The basic structure is that employers want to locate together
- Because of “Agglomeration Economies”
- That is, firm profits are higher when firms locate near each other
 - Due to access to employees
 - Access to customers- other firms and local labor
 - Transfer of technology (people talk)
 - Concentration of infrastructure- and many other possibilities

Effect of Agglomeration on People

- Because firms have demand to locate together, they bid up land prices
- So theoretically, all firms would locate downtown
- And people would want to be near firms, to keep their commuting costs down
- Thus land farther from downtown, or “central business district,” would be cheaper than land close to the CBD
- Result is called a “density function”: It describes the relationship between distance to the CBD and population density as:

Houston Linear Density Function: Land Density Falls as Land Prices Fall



Response to Demand for Location in the CBD

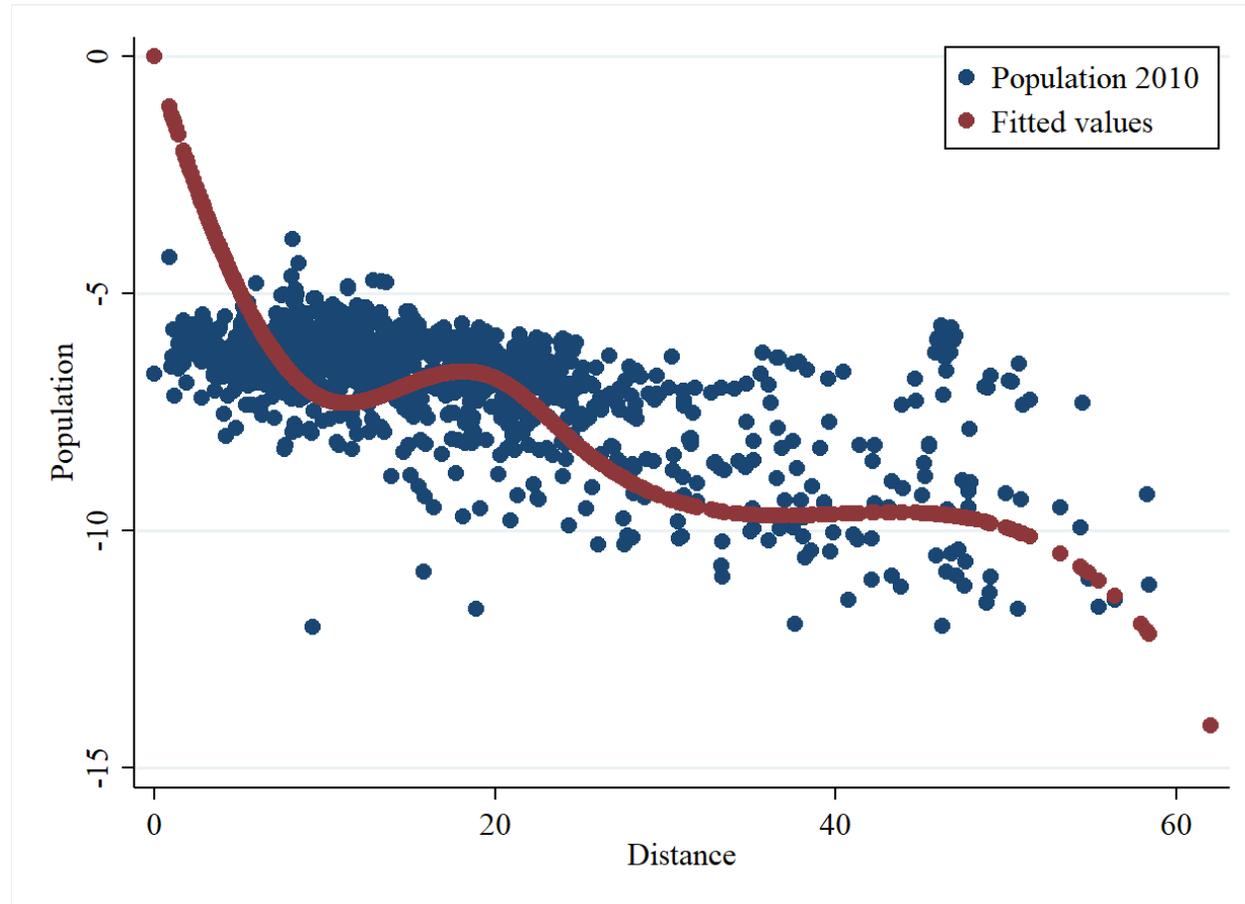
- Congestion in the CBD- which raises costs
- So the market response has been to create employment sub-centers
 - Galleria, Medical Center, Energy Corridor, Clear Lake, up to 16.
- Not industry concentrations. We find subcenters generally mirror downtown (vs. real estate names!)
- On average, employment is still closer to downtown than are residents- so most commuting is inward
- That is, residents only commute outward for personal circumstances
- The resulting density function for residents is therefore altered

The Cubic Spline Density Function

- In Houston, we have had some success at summarizing the resulting location of our employment subcenters
- We estimate a cubic spline function, which shows Houston's shape
 - This is simply a generalization, think of each point on the graph as being a concentric circle around the CBD
- The “low” points of residential density suggest that is where employment concentrations outside of downtown occur- or
- Employment Subcenters

Cubic Spline Density Function

Employment Subcenters at “local nadirs”
Think about concentric circles around CBD



Employment Subcenters

- We have done some academic work on employment subcenters, and how they affect the shape of the urban economy
- Subcenters are pervasive in cities across the US- and even the world
- Of course their location depends on local topography
- But also on the built infrastructure- like highways
- We have also found that their location is important for determining where Houston residents live
 - If one person works Downtown, and the other in the Galleria, then between them is superior to a Clear Lake location! And vice versa if the other person works in Clear Lake instead of the Galleria

Academic Qualifiers on Employment Subcenters

- There is not an agreed upon definition
- Everyone agrees the definition should include their size in terms of total employment, or share- especially conditional on distance from the CBD
- The more controversial part is whether the definition should be required to have influence on surrounding areas
 - We have published work which supports this view- and we utilize this definition to inform our forecasts
 - Which implies people are willing to pay to be closer to the subcenter, holding constant distance to the CBD
 - And as a result, the subcenters have varied influences on each other- although we don't yet incorporate this in our forecasts

Forecast is Based on Rotation of Density Functions

- The next question is how to develop a forecast. Over time, the density function for the city rotates outward as total population grows
 - Pivot around the point at the CBD (zero distance)
- Downtown residential density in Houston has been affected by City of Houston subsidy to residential construction
 - Unimportant for overall economic shape
- The close-in areas develop by in-fill, and redevelopment
- Overall, the city grows faster in the outlying areas
 - Land is cheaper
 - No demolition is required
- This makes the city expand its boundaries as transportation improves, and the density function becomes flatter

Forecasting Statistical Module

- We use Census data from 1970-2020, and statistically estimate the density functions each decade to understand how they have rotated over time
- Based on the resulting pattern, we forecast how the density function will rotate in the future
- The advantage of this process is greater accuracy
- Forecasts more rapid development in areas farther from the CBD
 - And the employment subcenter location suggests where growth is most rapid along the radii projecting from the CBD

Forecasting Land Use Module

- As you all know, history matters. In Economics, we call it fixed costs
- Parks, large facilities, and other locally-specific land uses impact population at the Census tract level
- The second part of our analysis develops what we call the Land Use Module
- We essentially convert the statistical forecasts into percent change, to be sensitive to the current land uses
- And sensitive to the control totals for each County (generated separately)
- Then we examine the potential forecast with respect to the vacant land available, using area specific residential densities
- If there is insufficient land to hold both the employment and population forecast, we use an algorithm to push people around to where there is available vacant land

Land Use Module, (cont)

- The information from the urban economics focus is important for suggesting alternative locations
- Specifically, to be sensitive to price, people will be about equi-distant from the CBD
 - Which is telling you that distance to the CBD is still most important everywhere
 - But, we find distance to the Galleria is also widely important
 - Other employment subcenters have much smaller areas of influence
- And to be sensitive to the employment center locations, they will want to be near the appropriate radii.

Long Range Forecasting

- Our process assumes the basic structure of the city stays about the same over time
- I mentioned that we were asked to forecast out to the year 2100
- Will the city economic structure stay the same this entire century?
- Simple answer, No.
- Why? 3 Parts
 - 1. Drop in demand for petroleum exploration
 - 2. Transportation Demand will Fall- batteries are made elsewhere
 - 3. Sea Level Rise, plus storms become more frequent and more severe
 - Though this impact depends crucially on public policy on infrastructure

Changes to Economic Structure: Reduction from Petroleum

- Part I of 3 part answer:
 - Manufacturing on the East Side, and traffic at the Port of Houston, are largely driven by the petroleum industry
 - Especially exploration- drilling equipment, pipe (where Houston supplies the world)
 - And oil exploration is going to decline, probably by a lot
- We don't seem to have another major "export" industry waiting in the "wings"
 - Export industries import wealth into the City
- And the alternative energy industries are not front and center here
- Public Policy: New Industrial Development
 - Both U of H and Rice are pushing on this front

Long Range Structure: What Powers Transportation?

- Part II of why the economic structure of Houston will change
- Transportation uses about 70% of total worldwide petroleum production
 - The aggregate investment by auto manufacturers in battery technology is staggering; easily \$200 Billion this decade alone
 - And you can already see the large number of Electric models coming out
- So even if global warming doesn't happen (it is), cars will be electric
- Doesn't mean petroleum demand goes to zero, but drastically reduced, and heading smaller over time
- And, batteries don't get made here in Houston

Part III of Long Run Change: Climate and Sea Level Rise

- Concern over Emissions will reduce demand for Petroleum
- And like batteries, we have not developed responses in our local economy
- More pertinent for our model are:
 - Floodplains will become more important- either for damage (ex post), or for prevention infrastructure (ex ante)- but still costs rise
 - Also increase in demand for emergency management infrastructure- flood control- and potentially local costs
 - Both of which will influence location of Population
- Flood Control and other Emergency Management polices matter

Impacts of Potential Economic Decline

- We studied several post-industrial cities in the US
 - Pittsburgh, Cleveland (OH), St. Louis, Birmingham
- And found the central city/central county of these metro areas declined in population over several decades
- Surprisingly to us, suburbs experienced continued (slower) growth

- We applied this pattern to post 2050 Houston. The central area is virtually constant, but the suburbs continue to grow
- This suggests to us a public policy problem with central cities being resilient- a subject of our continuing research

Policy Impacts on Houston's Future

- All of this environmental and economic stress will influence location
- The SAM-Houston model tries to incorporate the stress in two ways
 - Additionally to the flat-interior-growing-suburbs pattern above
- Floodplains
 - Using current data, people try to avoid 100 year Floodplains
 - Surprisingly, 500 year floodplains are attractive
 - We think this is reflecting relative value
 - So our model allows the area in the 100 year floodplain to expand over time, while the area in the 500 year floodplain decreases.
 - This is just a swap, we didn't add new areas to the floodplain
 - although that would be a useful innovation

Long Run Accommodations

- Our second step for climate accommodation is that Brazoria County opted out of the newly created Coastal Protection District
- =Brazoria will not be part of the Ike Dike
- No local taxes in Brazoria to pay the local share, but everywhere else
- But, no protection from sea level rise and its consequences in Brazoria
- Thus our model pushed people away from coastal Brazoria
- This accommodation is almost for sure either:
 - Too big (the Ike Dike is much more expensive than forecast)
 - Too small- the Ike Dike works like a charm, and Brazoria has no protection

Summary and Conclusion

- For Forecasting, “You never know what is going to happen next!”
- But, it provides a great opportunity to think about where we are going as a region
- We have some serious long run challenges that are only slowly penetrating the public policy sphere- but the changes are positive
- My other conclusion is that economics is an important additional tool that could be incorporated in growth forecasting more often
 - Especially in situations where the local areas of relative growth are important

Thank you!

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