PUI2015 Extra Credit Project – "Quick look" at Urban Metabolisms in Mexico, selection of 78 cities

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Abstract: Urban Metabolism studies could be important cornerstones of city planning and inform federal resource allocation. This analysis attempted to compare 78 Mexican cities across basic inputs and one output. These indicators were plotted against population. Further work should be done to standardize information and obtain variables that more comparable against each other, in addition to a time series analysis.

Introduction

A historic "centralized government policy" in Mexico has tended to focus all capital planning and government programs in three main urban areas in Mexico- the capital Mexico City, and main industrial and economic centers like Monterrey and Guadalajara. Mexico's population grew from 30 million in 1950 to over 120 million today, and the country is over 70% urbanized [INEGI], with more than half of the urban population living in poverty. An analysis of resource consumption in Mexico's could serve to decentralize planning and better reconcile each cities needs[3]. In terms of data, Mexico City just started an open data portal in 2014, and ICLEI has been working with 40 cities and municipalities in Mexico to help them start baselining their greenhouse gas emissions and outlining their local Climate Action Plans for reduction.

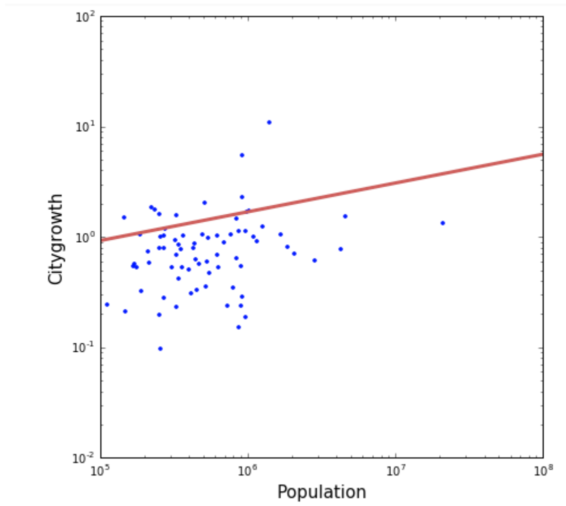
This analysis seeks to make an "urban metabolism" comparison of the top 78 cities in Mexico looking across 4 basic indicators: water consumption, fuel consumption, CO2 emissions and waste disposal. There is a theory of "science of cities" that claims they behave similar to large organisms (such as elephants) in terms of efficiency gains in resource consumption. A study by Bettancourt et. al. [1] looking at indicators for 350 US cities found that a doubling in city size only needed a 85% increase in infrastructure, resulting in 15% gains in efficiency. Studies in urban metabolism have been done for cities in the US, Portugal, Hong Kong, and a handful of others. For Latin America, there is one a comparative study [2] for four cities: Mexico City, Sao Paolo, Rio de Janeiro and Buenos Aires. These studies look at city inputs - water, energy and food- and outputs -GHG emissions, wastewater and solid waste. According to Kennedy [4] et. al, however, these gains have not led to a dematerialization of the economy, on the contrary, resource use continues to increase across the board, in tandem with affluence and population growth.

Data: Data for 78 cities was compiled by the Instituto Mexicano de Competencia (IMCO), aka Mexican Institute of Competitiveness, a Mexican research institute focusing on public policy. These indices are compiled every two years from national Secretariats. Indicators provided include: GDP, population, population density, water use (in m3 per capita), fuel consumption (in m3 per million of GDP), adequate disposal of solid waste and growth in city size (as % change in population). For carbon emissions, data was only obtained for 12 cities from their municipal Climate Action Plans, as the National Institute for Climate Change did not have the have granularity of data needed. In this case, not much data wrangling was needed, only normalizing data per capita to make it comparable and formatting accordingly.

Methodology: analysis was done in iPython notebooks, doing simple OLS regressions comparing population to other indicators to see if there was any relation.

Simple OLS regression yielded very poor results, run against population

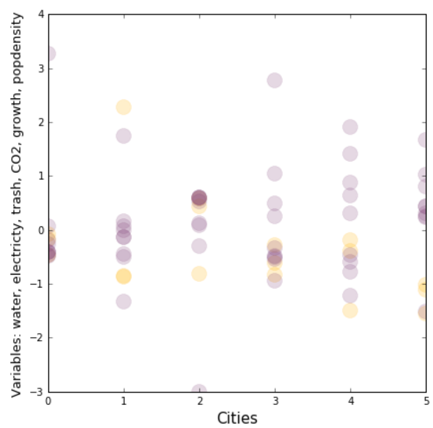
Variables	R-squared
City Growth (as % in population)	.007
Electricity use (fuel use	.003
Water consumption	.001



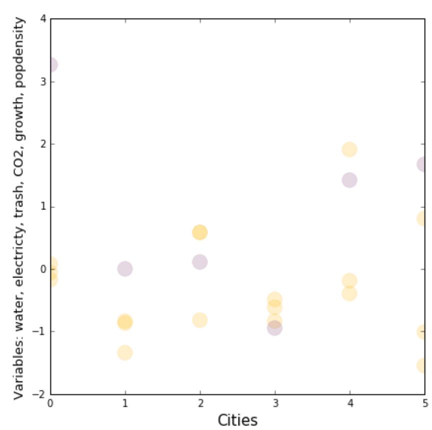
This was the only plot that actually had some weak relation, growth in city size (% change in population) against population.

Kmeans and agglomerative clustering was done to group the cities and see if the data had some structure. An array of values was done for clustering analysis was done to see if some cities have similar patterns. This was only done for the 12 cities for which I was able to obtain data on CO2 emissions by looking at each city's Climate Action Plan. Population was dropped because it was having a strong effect on the clustering. Mexico City's baseline for CO2 emissions was over 30 mtCO2e (million tons of CO2 equivalent) and the smallest was Poza Rica, with just over 1 mtCO2e.

Kmeans, 2 Clusters	
Cluster 1:	Toluca, Cuernavaca, Puebla-Tlaxcala – cities near large metropolitan areas
Cluster 2:	Aguascalientes, Valle de Mexico, Celaya Irapuato, Guadalajara, Oaxaca, Culiacan, Xalapa, Poza Rica- cultural tourist attraction cities

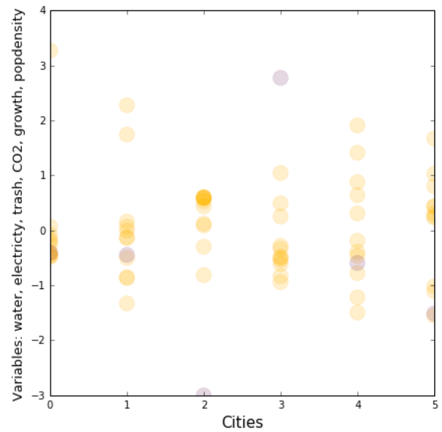


Kmeans, 3 Clusters	
Cluster 1:	Toluca, Guadalajara, Puebla-Tlaxcala – manufacturing cities
Cluster 2:	Valle de México- outlier always
Cluster 3:	Aguascalientes, Celaya, Irapuato, Cuernavaca, Oaxaca, Culiacan Xalapa, Poza Rica- – cultural, tourist attraction cities



Agglomerative Clustering

Agglomerative, 2 Clusters	
Cluster 1:	Toluca, Cuernavaca, Puebla-Tlaxcala Aguascalientes, Valle de Mexico, Celaya Irapuato, Guadalajara, Culiacan, Xalapa, Poza Rica
Cluster 2:	Oaxaca – cultural, tourist attraction cities
Agglomerative, 3 Clusters	
Cluster 1:	Toluca, Cuernavaca, Puebla-Tlaxcala Aguascalientes, Valle de Mexico, Celaya Irapuato, Guadalajara, Culiacan, Xalapa, Poza Rica
Cluster 2:	Oaxaca- small cultural city
Cluster 3:	Valle de México- capital, over 20 million people



Conclusions
Analysis show weak correlation in the variables, I believe they had to be further normalized. For the Clustering analysis, we (FBB and myself) whitened the data to make it more comparable.
Per the clustering analysis, my interpretation as to why there were clustered in those groups is it has to do with their main economic activities and overall characteristics, and the clusters make sense.

Future Work
This analysis may be work while if we could procure data for our missing inputs: food imports, waste water output, waste generation.

Links: Dataset from IMCO: http://imco.org.mx/indices/#!/

Map of Metropolitan areas by population, created in Carto DB.

References:
[1] Bettencourt, L. and West, G. *A Unified Theory of Urban Living.* Nature, Vol 467, October 2010.
[2] Delgado Ramos, G. C.; Campos, C.; Rentería, P. Climate Change and Urban Metabolism of Latin American Megacities. Hábitat Sustentable Vol. 2, N°. 1, (2012) 2-25 ISSN: 0719 - 0700
[3] Hoornweg, D. Mainstreaming Urban Metabolism: Advances and Challenges in City Participation. Working paper for Sixth Urban Research and Knowledge Symposium 2012.
[4] Kennedy, C.; Pincetl, S.; Bunje, B. The study of urban metabolism and its applications to urban planning and design. Environmental Pollution 159 (2011) 1965-1973