Development Economics: Replication Project

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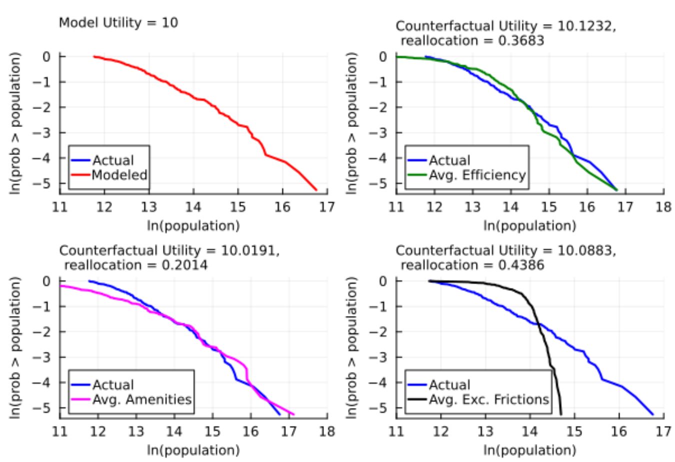
1 Introduction

This replication project aims to replicate five key results from Desmet, Klaus and Esteban Rossi-Hansberg (2013) "Urban Accounting and Welfare," *American Economic Review*, 103(6), pp. 2296-2327. Namely, the replication project replicates Figures 2, 3, and 4 from Section III and Figures 8 and 9 from Section IV. The results from all five figures are generated through the estimation of the model presented in Section I and Section IIIA, under varying parametric assumptions and assumptions pertaining to three key city characteristics, ie city efficiency, amenities and excessive frictions. The following report will proceed as follows. The replication of each result is presented first, followed by the result from the publication, an interpretation of the results, a description of the identifying assumptions for the interpretation and a description of how the results were generated in practice.

2 Figure 2

Replication results:



Publication results:

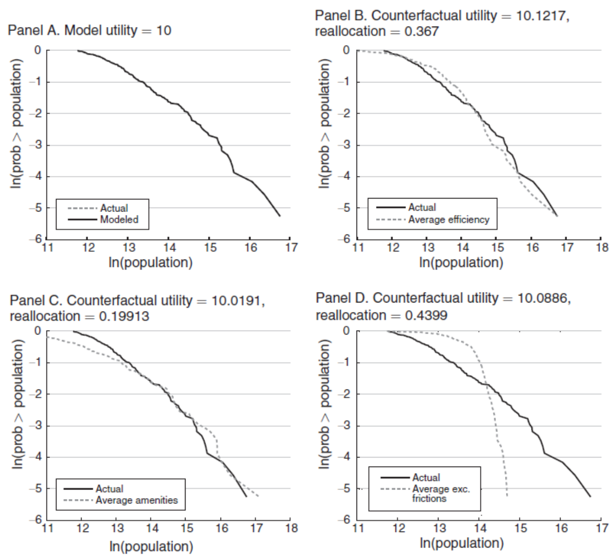


FIGURE 2. COUNTERFACTUALS WITHOUT DIFFERENCES IN ONE CITY CHARACTERISTIC, $\kappa = 0.002$

2.1 Figure 2: Description

All of the results presented in this replication project are generated using data produced by the scripts called *InputsNumericalUS* and *InputsNumericalChina*. The figures displaying results for the US utilize data generated by *InputsNumericalUS* and the figures displaying results for China utilize data generated by *InputsNumericalChina*. Both *InputsNumericalUS* and *InputsNumericalChina* utilize preliminary data containing information on wages, consumption, income taxes, rent, capital, population, and hours worked at the metropolitan or prefecture level, respectively. The *InputsNumerical* scripts first calculate the labor and efficiency wedges, before utilizing the model presented in Section I to identify and generate data measuring city population, efficiency and excessive frictions. The resulting data is then utilized in the *UAWMainUSA* and *UAWMainChina* scripts to conduct the counterfactual exercises that generate the figures for this replication project.

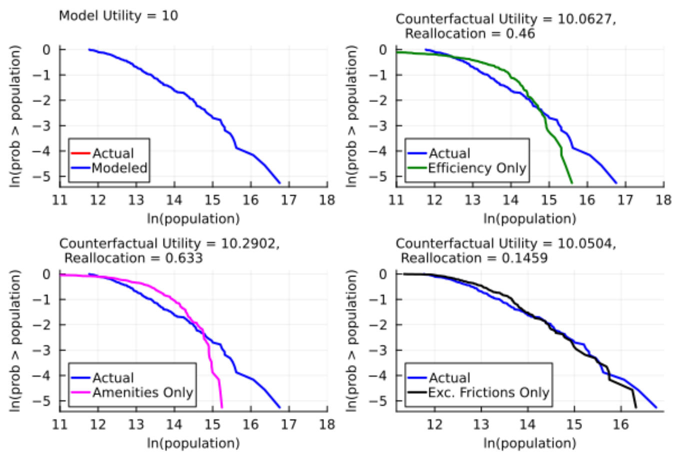
The results presented in Figure 2 were generated using the *UAWMain* script. The *UAWMain* script utilizes Equation (19) from Section IIIA to calculate the population of city i at time t. Equation (19) itself follows from Equation (11) of Section IE, which provides an an implicit function for city size as an equilibrium condition of the publication's model. Equation (19) determines the size of the city N_{it} as a function of a set of parameters including the commuting cost per mile (κ) and relative preference for leisure (ψ), a set of economy-wide variables including the national interest rate (r_t) and flat utility ($\bar{u}$), and the key city characteristics, ie. efficiency (A_{it}), amenities (γ_{it}) and excessive frictions (g_{it}), the data for which was calculated beforehand by the *InputsNumericalUSA* script. The purpose of the *UAWMain* script is to solve Equation (19) under multiple sets of assumptions, with each set of assumptions implying a unique set of conditions applied to the three city characteristics, in order to generate multiple counterfactual city size distributions. Figure 2 presents four city size distributions. As such, *UAWMain* will solve Equation (19) under four different sets of assumptions to generate a counterfactual city size distribution for each. The script utilizes the Roots.jl package in order to numerically solve the non-linear equation by finding its root under each set of assumptions. Furthermore, each counterfactual solution of Equation (19) also generates a counterfactual economy-wide utility level ($\bar{u}$), which is such that the resulting city sizes satisfy the labor market clearing condition, Equation (13). The resulting counterfactual utility level for each experiment is compared to the baseline utility level to ascertain the impact that reallocation has had on the utility of the representative consumer.

The *UAWMain* script first generates the city size distribution for the USA with the city characteristics given directly by the data generated by *InputsNumericalUSA*. The result is presented in Panel A of Figure 2. This city size distribution acts as the baseline for comparison with the city size distributions generated in the three counterfactual exercises. Next, the script solves Equation (19) for the city size distribution under the assumption that all cities possess the same efficiency (A_{it}), namely the population-weighted average efficiency of the distribution generated by *InputsNumericalUSA*. The result is presented in Panel B of Figure 2. The authors find that utility increases by less than 1.5 percent. Most large cities significantly decline in size, whereas smaller cities typically increase in size, although not without a significant number of exceptions. The script then solves Equation (19) for the city size distribution under the assumption that all cities possess the same level of amenities (γ_{it}), namely the population-weighted average level of amenities in the baseline distribution. The authors find that utility similarly increases by less than 1.5 percent. Changes in city sizes are now more mixed, with changes in large cities heavily depending on their coastal location. Lastly, the script solves Equation (19) for the city size distribution under the assumption that all cities possess the same excess frictions (g_{it}), namely the population-weighted average level of excess frictions in the baseline distribution. The authors find that utility again increases by less than 1.5 percent. Large cities shrink significantly in response to the resulting allocation, whereas small cities witness massive growth.

Overall, the counterfactual exercises presented in Figure 2 demonstrate that changes in key city characteristics would have massive reallocative effects on the distribution of cities in the USA. However, the utility of the average individual is not expected to improve significantly in proportion to the huge reallocation of the population that would ensue.

3 Figure 3

Replication results:



Publication results:

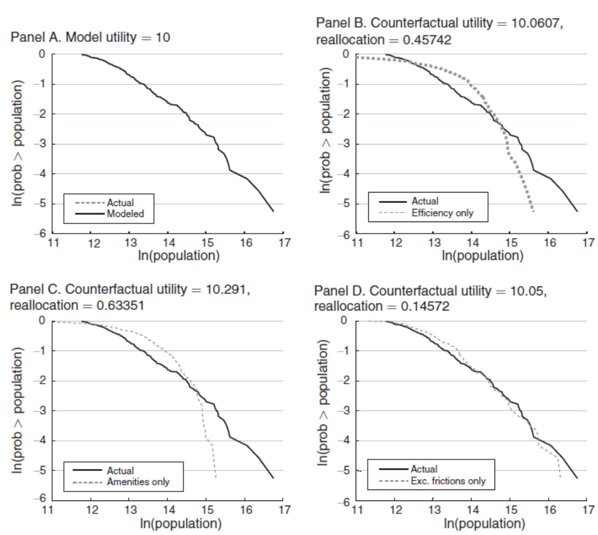


FIGURE 3. COUNTERFACTUALS WITH DIFFERENCES IN ONLY ONE CITY CHARACTERISTIC, $\kappa = 0.002$

4 Figure 3: Description

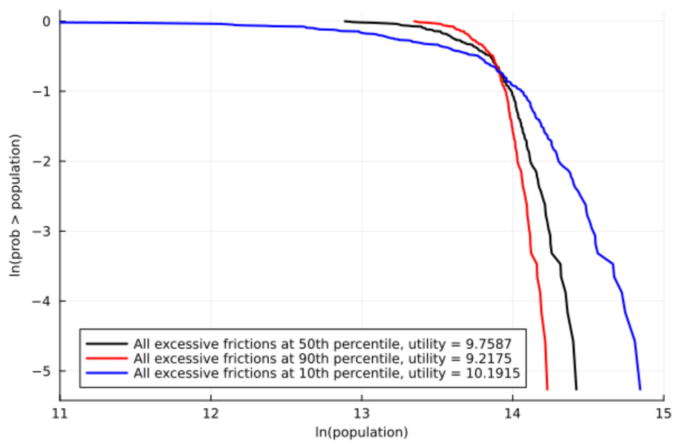
The results presented in Figure 3 were similarly generated using the *UAWMain* script. An explanation of the function of the script in relation to Figure 3 will be omitted, as it functions in the same way in generating Figure 3 as it did in generating Figure 2. The difference in the functionality of the script for generating Figures 2 and 3 lies in the assumptions that are made about the three key city characteristics when solving for the counterfactual city size distributions. When applying the script to generate Figure 2, each individual counterfactual exercise assumed that all cities within the distribution possess identical levels of a particular city characteristic, eg. city efficiency, amenities or excessive frictions. Three counterfactual exercises are also conducted to produce the results constituting Figure 3. Each counterfactual exercise is distinguished by a unique set of assumptions pertaining to the three key city characteristics. However, each counterfactual experiment now assumes that cities differ in only one key characteristic; meaning that cities are assumed to possess identical levels for two key characteristics.

The *UAWMain* script first generates the city size distribution for the USA with the city characteristics given directly by the data generated by *InputsNumericalUSA*. The result is presented in Panel A of Figure 3. Next, the script solves Equation (19) for the city size distribution under three different sets of assumptions. First, it is assumed that all cities only differ in their level of efficiency, meaning that they all possess amenities and excessive frictions equal to the means of the corresponding distributions. The results are presented in Panel B. Second, it is assumed that all cities only differ in their level of amenities, meaning that they all possess efficiency and excessive frictions equal to the means of the corresponding distributions. The results are presented in Panel C. Lastly, it is assumed that all cities only differ in their level of excessive frictions, meaning that they all possess efficiency and amenities equal to the means of the corresponding distributions. The results are presented in Panel D.

Similarly to the counterfactual exercises conducted for Figure 2, the representative consumer achieves meager increases in their utility relative to the enormous reallocation of population that occurs under the second and third counterfactual exercises, for example. The authors note particularly large reallocation away from the largest and smallest cities when cities are assumed to differ in their efficiency or amenities only. This suggests that the largest and smallest cities maintain their size due to a composition effect involving multiple city characteristics, rather than a comparative advantage in a single characteristic. Interestingly, assuming that cities only differ in their level of excessive frictions has relatively minimal effect on the city size distribution.

5 Figure 4

Replication results:



Publication results:

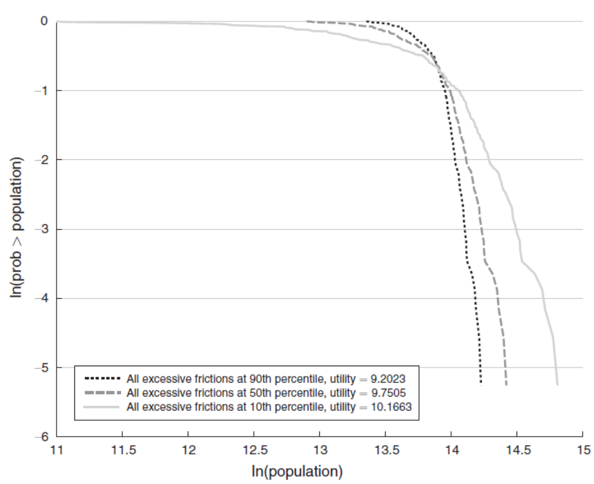


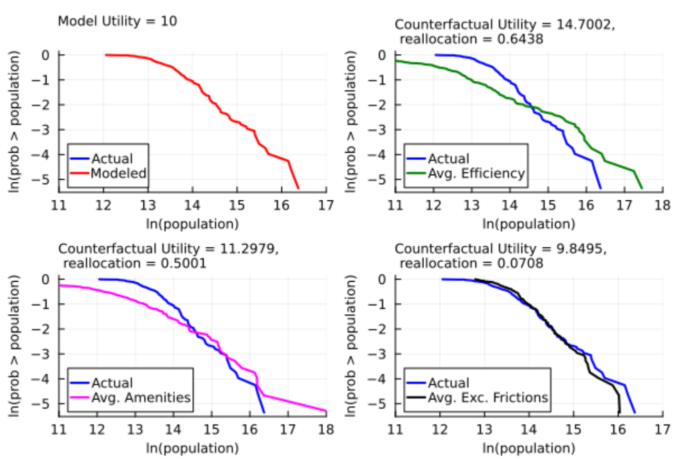
Figure 4. Changing the Level of Excessive Frictions

6 Figure 4: Description

The results presented in Figure 4 were again generated using the *UAWMain* script. Again, an explanation of the function of the script in relation to Figure 4 will be omitted, as it functions in the same way as it did in generating Figures 2 and 3. In fact, the results presented in Figure 4 are generated through a repetition of the third counterfactual exercise conducted to generate Panel D of Figure 2. More specifically, to generate Figure 4, *UAWMain* solves Equation (19) for the city size distribution under three separate sets of assumptions. In each set of assumptions, it is assumed that all cities have an identical level of excessive frictions. However, in each experiment, the level of excessive frictions that the cities are assumed to share may take on three distinct values. The three experiments assume that the shared level of excessive frictions is equivalent to the 10th, 50th and 90th percentiles of the initial distribution. The authors note that setting excessive frictions equal to the median already decreases welfare by 2.5 percent relative to the baseline. From there, decreasing excessive frictions to the 10th percentile leads to a significant widening of the city size distribution and an increase in welfare, whereas increasing excessive frictions to the 90th percentile leads to a relatively small contraction of the city size distribution, despite the notable decrease in welfare that follows.

7 Figure 8

Replication results:



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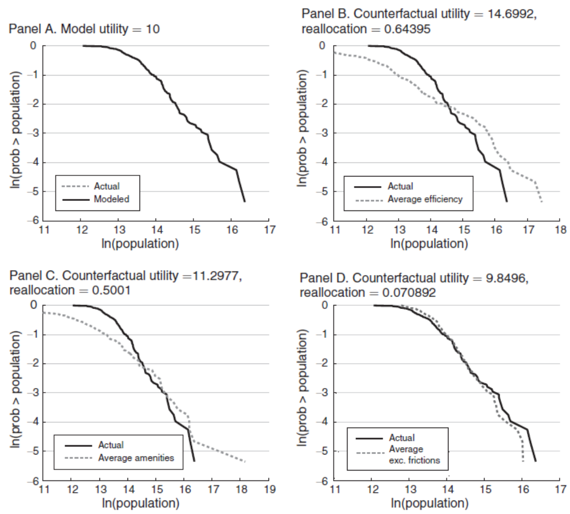


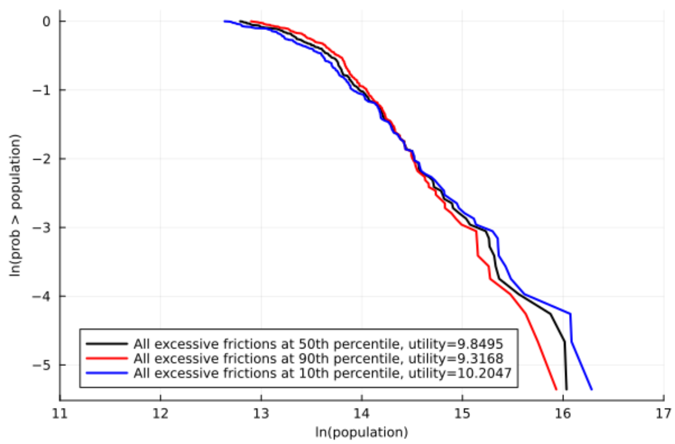
Figure 8. China Counterfactuals without Differences in One City Characteristic

8 Figure 8: Description

The results presented in Figure 8 are generated using the *UAWMain* script. In fact, the results in Figure 8 are produced through essentially an exact repetition of the counterfactual exercises conducted to produce Figure 2, only now the model from Section I is applied to data on Chinese prefecture-level cities, rather than American metropolitan statistical areas. Again, Plot A provides the baseline city size distribution that is implied by the city characteristics generated by *InputsNumericalChina*. Each counterfactual exercise in turn assumes that all cities have identical levels of one of three city characteristics, ie. city efficiency, amenities or excess frictions. The authors note that the total reallocation of the population in the counterfactual experiments is very similar to that in the same experiments for the US; however, the welfare changes for China are an order of magnitude larger than for the US. Chinese welfare would increase by 47 percent under equivalent efficiency and 13 percent under equivalent amenities. In comparison, American welfare would increase by 1.2 percent under equivalent efficiency and 0.2 percent under equivalent amenities.

9 Figure 9

Replication results:



Publication results:

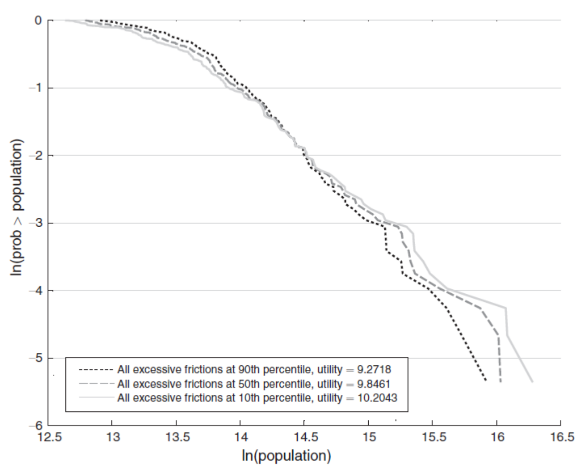


Figure 9. Changing Excessive Frictions in China

10 Figure 9: Description

The results presented in Figure 9 are generated using the *UAWMain* script. In fact, the results in Figure 9 are produced through essentially an exact repetition of the counterfactual exercises conducted to produce Figure 4, only now the model from Section I is applied to Chinese data. Once again, it is assumed that all cities possess an identical level of excessive frictions. This shared level of excessive frictions is set to the 10th, 50th and 90th percentiles of the initial distribution. The authors note that the changes in the size distribution of Chinese cities are even smaller than those in the US, but the welfare implications are approximately the same. Increasing excessive frictions to the 90th percentile implies a 5.8 percent decrease in welfare relative to the median baseline, whereas decreasing excessive frictions to the 10th percentile implies a 3.5 percent welfare increase relative to baseline. Overall, the average level of excessive frictions in China is the same as in the US, but they play a smaller role in determining the city size distribution in the former than in the latter.

11 Conclusion

Overall, this replication project has presented replications of five key exhibits from the publication. It can be seen from the graphs presented that the replication produces results that exactly match those presented in the paper. It is important to note that the results presented above heavily depend on the assumptions which determine the functional form of the model that is presented in Section I. This is true for multiple reasons. Firstly, the empirical approach of the publication is based on the model and its general equilibrium nature. The regression model specifications that are used to estimate the "effects" of the three city characteristics on city size depend on the causal relationships implied by the model. The authors' decision to decompose the city size distribution ($\log N_{it}$) in Equation (12) and the "labor wedge" ($\log \tau_{it}$) in Equation (15) into two parts, whilst decomposing median rents ($\log(AR_{it})$) into three parts, with each of the three parts corresponding to the effect of a city characteristic, is justified directly by the model. Secondly, the counterfactual exercises conducted in Section III of the publication heavily depend on the model specification. In order to calculate the counterfactual city sizes for each experiment using Equation (19), one must first obtain values for the three city characteristics. Efficiency can be calculated directly from available data, but requires an assumption on the form of the production function. Excess frictions are calculated by assuming that they are equivalent to the error term of Equation (20) - both the regression specification and the identification of excess frictions with the error term are decisions that directly depend on the model. Lastly, city amenities are calculated by finding the values of γ_{it} that set the observed city size distribution equal to that implied by the model. Fortunately, further analysis by the authors demonstrates that the values generated by this approach correlate very closely to proxies found in the data.