0.1 For the text

The location-specific elasticities are central to our quantitative assessment of the UMT. In Table 4, we show variations in how those elasticities are determined, and that the importance of the UMT remains robust. Row 1 shows our baseline results, with the rural elasticity set to $\epsilon_r = 1.2$, and the formal and informal elasticities calibrated so that the model matches the targets shown in Table 2. Those targets are the average urbanization rate and informal share in our baseline sample of 43 countries.

We can instead calibrate the model for *each* country separately, given a rural elasticity of $\epsilon_r = 1.2$, and get values of ϵ_f and ϵ_l unique to each country. Rows 2 and 3 of Table 4 show several pieces of information. First, while the mean value of the formal elasticity is high compared to our baseline elasticity, the median formal elasticity from the 43 separate calibrations is only slightly higher than the baseline elasticity. For the informal elasticity, both the mean value and the median from the 43 separate calibrations are very close to our baseline value. Both indicate that using averages from those 43 countries as our targets did not skew our results. Columns 5 and 6 of rows 2 and 3 show that the results if we simulate the model using the mean or median elasticities. In both cases, the difference in urbanization and informal share without the UMT is similar in size to our baseline calibration, as can be seen by comparing rows 2 and 3 to row 1.

In the next panel of the table, we look instead at whether the chosen initial value for ϵ_r is responsible for our results. The original value of $\epsilon_r = 1.2$ was drawn from Lee (XXXX), but within that source there is some variation in the size of the implied rural elasticity. In Row 4 if we set $\epsilon_r = 1.6$, at the high end, and re-calibrate the model, the implied value of the formal elasticity if $\epsilon_f = 1.500$, with an informal elasticity of $\epsilon_l = 0.813$. All the elasticities are shifted up in size, but note that the pattern across elasticities remains similar, with the informal elasticity around half of the rural value, and the formal elasticity near the rural one. In this case, the model says the UMT explains slightly less urbanization (8.2 percentage points) and informalization (6.8 percentage points) than our baseline model. In Row 5 we instead set $\epsilon_r = 1.0$, at the low end, and re-calibrate once more. As expected, all the elasticities are shifted down, with a formal elasticity of $\epsilon_f = 1.189$ and an informal elasticity of $\epsilon_l = 0.553$. The results imply that the UMT explains 10.2 percentage points of urbanization, and 9.8 percentage points of informalization, both slightly more than our baseline. These results show that what is important in driving our outcomes is not the absolute level of the elasticities, but their pattern across locations.

This holds true in Row 6, where we approach setting the rural elasticity from an entirely different direction. Here, rather than starting with an aggregate estimate of the elasticity, we build up the aggregate elasticity from underlying sources. In the Appendix, we have written out an explicit model, but the aggregate elasticity is made up of four parts: (a) the elasticity of wages with respect to the number of workers, which can be inferred from the factor share of land and capital, (b) agglomeration effects, measured as the elasticity of productivity with respect to the number of workers, (c) housing effects, measured as the elasticity of housing prices with respect to population, weighted by the expenditure share on housing, and (d) amenity effects, measured by the elasticity of amenity value with respect to population, weighted by a measure of how important amenities are in welfare. For each of these four components, we can draw on estimates from the literature to build up an aggregate elasticity for a given location.

For the rural location, we find a factor share of land and capital in developing countries of around 0.56 (cites XXXXXX). For agglomeration, there is no significant evidence of any in rural areas (cites XXXX), so we set this to zero. For housing, the expenditure share appears to be close to 10% (cites XXXXX) while the elasticity of house prices with respect to population is close to 2.0 (cites XXXXX). Finally, for amenities sources indicate a welfare weight of 0.1 (cites XXXX), and in the rural location the elasticity of amenities with respect to population may be as high as 0.25 if one accounts for natural amenities. In sum, the rural elasticity is thus $\epsilon_r = 0.56 + 0 + .1 \times 2.0 + 0.1 \times 0.25 = 0.785$. This is lower than the original aggregate elasticity we set, but if one examines the results in Row 6 of Table 4, the implied effects of the UMT are not substantially different if we use this to calibrate the model, and are in fact larger with this lower assumed rural elasticity.

Also in Row 6 can be found the calibrated values of the formal (1.075) and informal (0.458) elasticities. These were set by the calibration so that we matched our targets exactly, not built up from the underlying sources. However, we can perform similar calculations for these locations, and those elasticities can be found in Row 7. For the formal location, the factor share of capital and land is closer to 0.6 (cites XXXXX), slightly higher than in the rural location. We find estimates of the agglomeration elasticity of 0.036 (cites XXXX). For housing, a similar expenditure share is found of 10%, and the elasticity of house prices with respect to population is set to 4.0 (cites XXXX). Finally, for amenities, there does not appear to be any significant relationship of amenity value to population size (cites XXXX), so this is set to zero. In sum, the formal elasticity is $\epsilon_f = 0.6 - 0.036 + 0.1 \times 4.0 + 0 = 0.964$, where note the agglomeration effect is subtracted, as ϵ_f is capturing the negative effect on welfare from additional population, whereas agglomeration has a positive effect. In informal locations, we perform a similar exercise, and find that the factor shares of capital and land are 0.3, while the agglomeration effect is actually larger than in formal areas, at 0.075 (cites XXXX). For housing, the expenditure share is still 10%, but the elasticity of house prices with respect to population is found to be 2.0 (cites XXXX). Finally, similar to the formal location, there does not appear to be any significant effect on amenities of population size, so this effect is zero. In sum, the informal elasticity is $\epsilon_l = 0.3 - 0.075 + 0.1 \times 2.0 + 0 =$

Just as we did with the rural location, we have built up separate estimates of the elasticities for these locations using similar sources to the rural location. In Row 7, one can see those elasticities that we infer from the literature. Comparing Row 7 to Row 6 shows that the calibrated elasticities are quite close to those inferred from the literature, suggesting that the variation across locations in elasticities we find is reasonable. While the elasticities from the literature are all shifted down relative to our baseline, the pattern of a low informal elasticity remains. We believe this gives some assurance that our baseline calibration is picking up real differences across locations in the welfare impacts of population growth, and in turn that implies a significant role for the UMT.

0.2 Individual utility

Let individual utility be described by the following

$$V_j = \omega_c \ln c_j + \omega_h \ln h_j + \omega_q \ln Q_j + \omega_d \ln(1/CDR_j). \tag{1}$$

where c_j is consumption of non-housing goods and services, and h_j is consumption of housing services. The preference weights ω_c and ω_h fulfill, without loss of generality, $\omega_c + \omega_h = 1$.

The amenity value Q_j and the crude death rate CDR_j are taken as given by an individual in location j.

They choose, however, the amounts of c_j and h_j to purchase. The budget constraint facing an individual in location j is

$$w_j = c_j + p_j h_j \tag{2}$$

where p_j is the price of housing (relative to consumption goods), and w_j is the wage. Optimizing over consumption and housing, we get that $c_j = \omega_c w_j$ and $h_j = \omega_h w_j / p_j$. This results in utility of

$$V_j = \ln w_j - \omega_h \ln p_j + \omega_q \ln Q_j + \omega_d \ln(1/CDR_j) + \Omega, \tag{3}$$

where $\Omega = \omega_c \ln \omega_c + \omega_h \ln \omega_h$.

For our purposes, we care about the growth rate of utility in each location, which is given by

$$\hat{V}_j = \hat{w}_j - \omega_h \hat{p}_j + \omega_q \hat{Q}_j - \omega_d C\hat{D}R_j. \tag{4}$$

We can evaluate each of these separate terms to find the effect of population growth on utility growth.

Wages: To determine the wage in a given location, we assume a production function of the form

$$Y_j = A_j K_j^{\alpha_j} X_j^{\beta_j} N_j^{1-\alpha_j-\beta_j} \tag{5}$$

where A_j is productivity, K_j is capital, and X_j is land. Note that the shares α_j and β_j are unique to a given location. Assuming that labor earns its marginal product, the wage in location j is given by

$$w_j = 1 - \alpha_j - \beta_j A_j K_j^{\alpha_j} X_j^{\beta_j} N_j^{-\alpha_j-\beta_j}. \tag{6}$$

We can allow explicitly for agglomeration effects by letting productivity be a function of the labor force, as in

$$A_j = B_j N_j^{\gamma_j} \tag{7}$$

where B_j is the inherent productivity in location j, and $\gamma_j > 0$ captures the agglomeration effect in location j.

With this specification for productivity, and the expression for the wage, the growth rate of the wage is given by

$$\hat{w}_j = \hat{a}_j^w + (\gamma_j - \alpha_j - \beta_j)\hat{N}_j, \tag{8}$$

where $\hat{a}_j^w = \hat{B}_j + \alpha_j \hat{K}_j$ is the growth of productivity and capital that is independent of the growth rate in the labor force. The effect of growth in the labor force may be positive or negative, depending on how big the agglomeration effects (γ_j) are relative to the importance of capital and land in production ($\alpha_j + \beta_j$).

In terms of our baseline model, we can write the above as

$$\hat{w}_j = \hat{a}_j^w + \epsilon_j^w \hat{N}_j, \tag{9}$$

where $\epsilon_j^w = \gamma_j - \alpha_j - \beta_j$ is the elasticity of the wage with respect to population size.

Housing: The second term in utility growth involves the price of housing. Given some limitations on housing due to land constraints and/or regulations, then it should be the case that prices are rising with N_j.

We could write this in a reduced form as

$$\hat{p}_j = \hat{a}^h_j \epsilon^h_j \hat{N}_j \tag{10}$$

where ϵ^h_j is the elasticity of the housing price with respect to population size. The value $\hat{a}^h_j$ is exogenous growth in the housing price in location j for any reason unrelated to population size.

Amenities: The third term in utility growth involves amenties. Assuming some effect of population size on the quantity (or implicit value) of amenities available, then we could write, again in reduced form,

$$\hat{Q}_j = \hat{a}^q_j + \epsilon^q_j \hat{N}_j. \tag{11}$$

Here, $\hat{a}^q_j$ is exogenous growth in the value of amenities, and ϵ^g_j is the elasticity of amenities with respect to population size.

Crude death rate: As stated in the main paper, we are taking the growth of crude death rates to be exogenous, and unrelated to population size.

Reduced form welfare growth: Combining the information about the different components of utility growth, we can write

$$\hat{V}_j = G_j - \epsilon_j \hat{N}_j - \omega_d C\hat{D}R_j \tag{12}$$

where

$$G_j = \hat{a}^w_j - \omega_h \hat{a}^h_j + \omega_q \hat{a}^q_j \tag{13}$$

is the exogenous growth in wages, housing prices, and amenities, where each are weighted as in the utility function. Similarly, the combined elasticity term, ϵ_j is

$$\begin{aligned} \epsilon_j &= \epsilon^w_j - \omega_h \epsilon^h_j + \omega_q \epsilon^q_j & (14) \\ &= \gamma_j - \alpha_j - \beta_j - \omega_h \epsilon^h_j + \omega_q \epsilon^q_j & (15) \end{aligned}$$

where the second line shows the explicit role of agglomeration effects (γ_j) and the production function parameters (α_j and β_j) on the elasticity. WHile the value of γ_j is expected to be positive, note that the rest of these terms would act to make ϵ_j negative. The values of α_j and β_j indicate how quickly wages decline with the number of workers. The relationship of housing prices to population size is presumably positive, so the term $\omega_h \epsilon^h_j$ is positive, and so acts to make the overall elasticity negative as well.

0.3 Parameter values

The expression in (15) shows us what explicit types of information we need to quantify the aggregate elasticity of welfare with respect to population size. For each in turn, we can evaluate them based on outside literature. Ideally, we would be able to provide a separate estimate of the parameter by location, although as we will describe below, this will not always be feasible.

Factor shares: The values of α_j and β_j (which capture the importance of capital and land in production in location j, respectively), can be estimated from factor share information. Individually, α_j and β_j would be equal to the factor share of capital and land, assuming factor markets are competitive. Alternatively, their sum, $\alpha_j + \beta_j$, could be recovered if we know the *labor* share in a location.

The major issue here is that factor shares are not reported by location, but typically only by sector. So in order to leverage factor share information, we first have to take some position on what sectors belong to which locations. Of course, many of these sectors operate in all locations (i.e. retail) so there is not a one-to-one mapping. Rather, we think of the locations as having different weights on which sectors are relatively important.

In the rural location, the agriculture is obviously going to be the dominant sector, with smaller weights on manufacturing and services activities. For the formal sector, we believe that the factor shares will be driven by sectors involving heavy manufacturing (i.e. chemicals or equipment), wholesale trade, information, and services like finance. For the informal sector, the factor shares will depend mainly on sectors like light manufacturing (i.e. textiles), retail and/or commerce, and personal services.

Valentinyi and Herrendorf (2008) provide estimates of the combined land and capital shares, $\alpha_j + \beta_j$, for several broad sub-sectors of the U.S. economy. In agriculture, this share is 0.54, suggesting that $\alpha_r + \beta_r = 0.54$ may be a decent estimate. Restuccia and Santaeulalia-Llopis (2017) find a similar share of 0.58 for Malawi, and Chen, Restuccia, and Santaeulalia-LLopis (2017) give a share of 0.58 in Ethiopia. For agriculture, we use a value of 0.56.

For the formal location, Valentinyi and Herrendorf's data is less useful, because it remains (for us) at a very high level of aggregation, with services all lumped together and the aggregate of manufacturing consumption (with a capital/land share of 0.40) also being somewhat broad. Young (2010) looks at labor shares at a more disaggregate level for the United States, and over a longer period of time, but does not make the same adjustments for proprietors income that Valentinyia nd Herrendorf do. With that caveat in mind, Young's numbers show high labor shares, and hence low values of $\alpha_f + \beta_f$ for several sectors we consider associated with formal locations. Utilities, both gas and electric, have implied values of $\alpha_f + \beta_f = 0.657$. Finance has an implied value of $\alpha_f + \beta_f = 0.556$, and communications gives an implied value of 0.503. Heavy industries such as chemicals and oil products have labor shares that gives values around $\alpha_f + \beta_f = 0.50$. Zuleta et al (2009) use data from Colombia, giving us something more appropriate in a developing context. Their capital shares suggest values of $\alpha_f + \beta_f = 0.743$ for public services, $\alpha_f + \beta_f = 0.487$ for manufacturing, and $\alpha_f + \beta_f = 0.625$ for finance. Using KLEMS data from India, which has reported labor shares by sub-sector, we find that heavy manufacturing industries, as well as business services, have implied values of $\alpha_f + \beta_f$ greater than 0.6. Based on all this information, we set the value of $\alpha_f + \beta_f = 0.6$.

In constrast, for sectors we associate with informal locations, Zuleta et al find $\alpha_l + \beta_l = 0.180$ for commerce and food service, $\alpha_l + \beta_l = 0.230$ for social and personal services, and $\alpha_l + \beta_{=}0.274$ for transport and storage. This is in line with the numbers from Young (2010), who find $\alpha_l + \beta_l = 0.227$ for trade in the U.S., and $\alpha_l + \beta_l = 0.311$ for services in general. Certain manufacturing sub-sectors, such as apparel, also have estimates of high labor shares, suggesting $\alpha_l + \beta_l = 0.152$. Valentinyi and Herrendorf's broad service sector has a capital share of 0.34, above these individual estimates. The KLEMS data from India reports the smallest implied values of $\alpha_l + \beta_l$ to be around 0.150-0.400 for personal services, health and social work, and food service. To be conservative, we set the $\alpha_l + \beta_l = 0.3$.

Agglomeration effects: The value of γ_j has been estimated XXXXX, and appears to have a maximum value of $\gamma = 0.10$. As the aggomeration effects are typically estimated using developed countries, we feel that this estimate is applicable to formal urban locations, so $\gamma_f = 0.10$. Whether there are similar agglomeration effects at work in informal or rural locations is arguable.

Assuming that agglomeration effects only operate in formal locations works *against* our findings, as it narrows the gap between the formal elasticity, ϵ_f and the informal elasticity, ϵ_l. With a smaller gap, the effect of the UMT would have been smaller in pushing people towards informal locations.

Housing prices: For the effect of prices, we need both the expenditure share, ω_h and the elasticity, ϵ_j^h. For the expenditure share, the average for housing expenditures for our baseline sample, from XXXXX in 19XX, is about 10%. This low value is due to their relative poverty. For the same set of countries, the expenditure share on food is over 50%. However, even if we were to assume a larger expenditure share on housing, similar to shares in developed countries, this will not result in an appreciable different in the results we find.

The elasticity, ϵ_j^h, is the percent change in prices given the percent change in the number of population, N_j. Assuming that population and the number of housing units are proportional within a given location (which does not require that the household size is similar across locations), we can use estimates of the elasticity of prices with respect to the number of households. Saiz (2010) finds that this elasticity varies with the strictness of the land use regulations, as measured by the Wharton Regulation Index (WRI) from Gyuorko, Saiz, and Summers (2008). Saiz's results imply that the difference in the elasticity ϵ_j^h between the least (10th percentile) and most regulated markets (90th percentile) is 0.228. If we instead use the maximum and minimum observed values of the WRI, this indicates s difference in ϵ_j^h between cities of 0.521.

Given that informal locations within developing countries likely have fewer regulations than even the lightest-regulated U.S. city, we use the difference of 0.521 to distinguish formal from informal locations. Using Saiz's central estimate of the elasticity of 0.650, this implies that the formal elasticity is $\epsilon_f^h = 0.911$ and the informal elasticity is $\epsilon_l^h = 0.390$. Combined with the expenditure share, this implies that $\omega_f \epsilon_f^h = 0.091$ and $\omega_l \epsilon_l^h = 0.039$. For rural areas, we presume that they too have very few land use regulations, and so set the term $\omega_r \epsilon_r^h = 0.039$ as well.

Amenities: For amenities, we need to establish both the utility weight ω_q, as well as their elasticity with respect to population, ϵ_j^q. Estimates indicate that the elasticity is close to zero, after controlling for natural amenities such as weather and coastal locations that are insensitive to population, as in Albouy (2008). Duranton (2016) finds no effect of amenities on wages within cities, indicating that there is no trade-off at work, consistent with a utility weight of $\omega_q = 0$. Chauvin et al (2016) find no relationship of weather and wages in China and India, perhaps indicating that at low levels of development amenities (of whatever form) are not valued very highly in welfare, again indicating a value of $\omega_q = 0$. Albouy (2012) finds that the quality of life does not significantly differ by city size, suggesting ϵ_j^q is close to zero as well.

If we did allow for a non-zero weight on amenities, $\omega_q > 0$, then Diamond's (2016) results on the difference in the response to amenities by schooling suggests that formal locations likely have a larger elasticity than informal locations, $\epsilon_f^q > \epsilon_l^q$. This is consistent with our calibrated finding of a larger formal elasticity, but the other evidence suggests that these elasticities are both quite small, even if non-zero.

Table 1: **DIFFERENT ASSUMPTIONS ON LOCATION ELASTICITIES**

Scenario	Elasticities: Rural (ϵ_r)	Formal (ϵ_f)	Informal (ϵ_l)	Actual vs. no-UMT Urb. Rate	Inf. Share	Welfare Ratio	Model Urb. Diff
1. Baseline	1.200	1.293	0.640	-9.4	-8.5	1.09	0.20
Calibrating to each individual country:							
2. Mean elasticities	1.200	1.763	0.687	-7.7	-8.3	1.09	-6.25
3. Median elasticities	1.200	1.407	0.647	-9.0	-8.6	1.09	-1.53
Alternative rural elasticities:							
4. Higher value from Lee	1.600	1.500	0.813	-8.2	-6.8	1.15	0.20
5. Lower value from Lee	1.000	1.189	0.553	-10.2	-9.8	1.06	0.20
6. Rural elasticity inferred from literature:	0.785	1.077	0.460	-11.4	-11.8	1.03	0.20
Alternatives for all elasticities:							
7. All elasticities inferred from literature:	0.785	0.964	0.425	-13.2	-12.2	1.02	5.43
Other results:							
8. Rural elasticity inferred from share:	0.560	0.960	0.362	-13.1	-15.3	1.01	0.20
9. Rural elasticity inferred from share, house:	0.760	1.064	0.449	-11.5	-12.1	1.03	0.20
10. All elasticities set from share:	0.560	0.600	0.300	-18.5	-10.3	0.97	22.95
11. All elasticities set from share, agg:	0.560	0.564	0.225	-21.9	-15.7	0.92	32.40
12. All elasticities set from share, agg, house:	0.760	0.964	0.425	-12.9	-12.2	1.02	4.28

Notes: Row 1 of the table shows the average urbanization rate and informal share, as well as the relative size of the total urban population, for a set of 18 historical countries. See text for the exact countries and the sources of the data. Row 2 shows the results of simulating our model, using the parameters listed in Table 2, except for setting the initial urbanization rate to match the historical data in 1800, setting the initial demographic rates to match averages from the 18 countries, and setting the half-life of the UMT to be 50 years (as opposed to 3 in our baseline model). Row 3 replicates Row 2, but replaces the exogenous fertility process with the endogenous fertility process described in the Appendix. In Rows 4 and 5, we simulate the model again using the same conditions in Rows 2 and 3, respectively, but setting the half-life of the UMT to be only 3 years (matching the UMT in our baseline).