Projecting future urban density change

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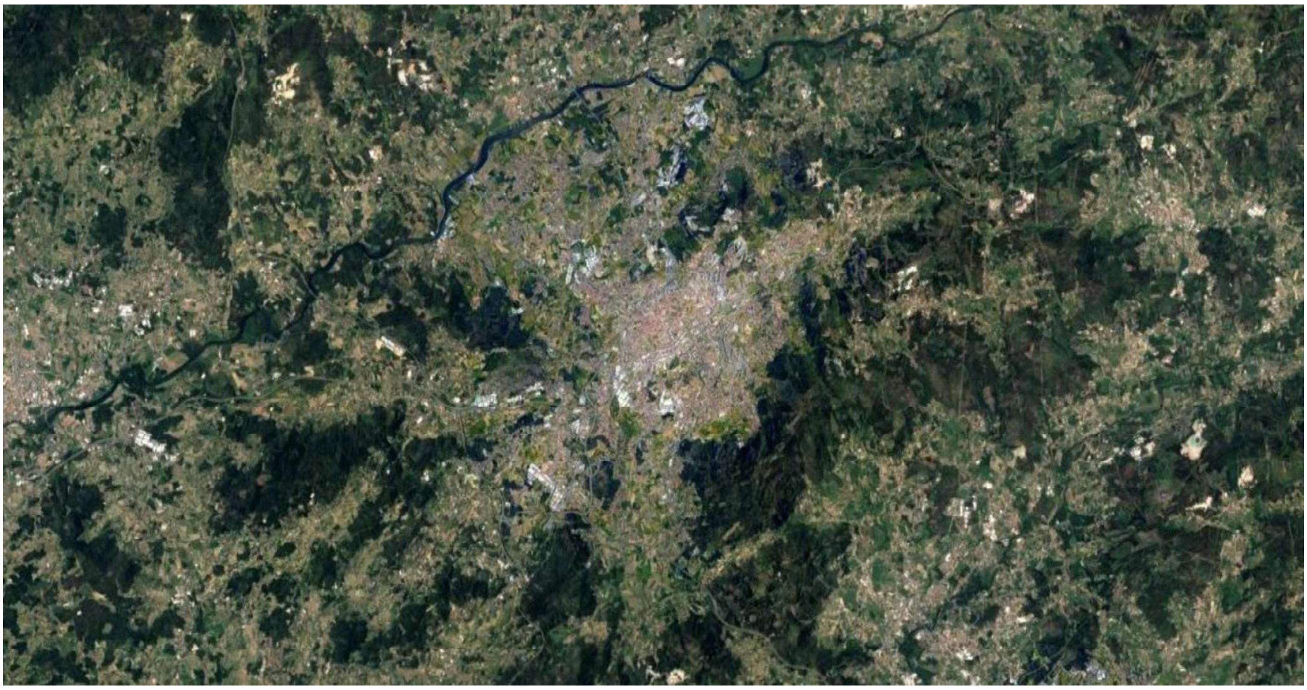

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This study aims to enrich our understanding of urban expansion at a global scale and focusses on the importance of changes in urban density to explain urban area development. The presented analysis supports the development of country-specific, future projections of total urban area that can be used in global assessment models. Such projections typically calculate urban area demand as a function of total urban population and an assumed urban land take per person. While population projections are well-established (e.g., Chen et al., 2020), urban density projections have received much less research attention.

As we are interested in understanding changes in urban density over time, we have set up a time series representing 134 countries around the globe for which we describe urban density and several explanatory variables. In this case the observations of the dependent variable (urban density) are related across time because each individual country is included multiple times. This makes it inappropriate to apply regular (OLS) regression analysis. Instead, we use a panel regression approach with country-fixed effects. This setup fits our purpose as we are not interested in explaining the variation in density levels between countries but want to know what is driving changes in density. So, our focus is on understanding what is affecting changes in density levels over time and not so much on replicating how differences between countries arose.

To characterise urban density, we rely on the global built-up area and population data distribution as provided by the European Commission's-Joint Research Centre. This so-called Global Human Settlement Layer (GHSL) offers a long and consistent time series capturing four moments in time: 1975, 1990, 2000 and 2015 (Florczyk et al., 2019). While this data set is known to contain inaccuracies (see, e.g., Kuffer et al., 2022), we consider this the best possible data set for our analysis. As our analysis results are intended to be applicable in the global 2UP model that simulates land use and population, we follow the model's definition of urban area: any 30 x 30 arc seconds grid cell where the percentage built up of the total land area is 50% or higher (for more details, see: Koomen et al., 2023). So, our urban areas are clusters of built-up area pixels in the original GHSL data set (with a 38-metres resolution) that cover at least around 0.5 km2 within a larger grid cell of circa 1 km2. Smaller clusters are considered to represent non-urban areas. All population within the urban cells is counted as urban population, while the population in the remaining grid cells qualifies as non-urban population. This approach has the advantage that we do not follow administrative definitions of urban areas that may differ per country.

In addition to the (urban) area and population data originating from the GHSL-source, our regressions include GDP per capita that we can match to the four years observed in the GHSL (1975, 1990, 2000 and 2015). Applying fixed effects per country yields coefficients that control for any unobserved heterogeneity per country, in addition to absorbing any time-invariant variables. This makes it impossible (and irrelevant) to include specific reference to local geographic conditions such as average elevation, climatic conditions etc.

The regression results indicate that urban density increases with increasing total urban population, but decreases, with increasing national income per capita, suggesting that higher incomes enable suburbanisation with more dispersed urban areas. We, furthermore, find that increasing levels of urbanity (proxies by higher shares of urban population) correspond to lower densities. A result that may hint at increased low-density suburbanisation when countries become more urbanised. The basic effect of the urban population fraction gets more pronounced when we add an interaction with total urban population. The interaction term itself indicates that the urban population fraction impact is less prominent for countries with larger urban populations.

Using our explanatory model of urban density we determine country-specific future urban areas per shared socioeconomic pathway (SSP, see: O'Neill et al., 2014). These resulting national area estimates are subsequently used as input in the 2UP model to simulate local urban area change. These high resolution results help analyse , amongst others, future climate impacts. For this study, we use the SSP database hosted by the International Institute for Applied Systems Analysis (IIASA, 2016). This presentation discusses the regression results, its application in the 2UP model and the future urban area projections this generates. We present several alternative specifications and show how data formatting, explanatory variables and scenario-specific assumptions impact the outcomes.

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