

Heterogeneous responses to built environment improvements in nonroutine activity participation among family types

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Introduction

As global urbanization accelerates, urban infrastructure continues to expand. Even within the same city, not all the citizens can benefit from urban development, especially the vulnerable group such as mother or elderly who face spatial and socioeconomic constraints. To achieve sustainable, inclusive, and affordable cities, it is essential to disentangle the mechanisms that drive such heterogeneity and inequality.

This study conceptualizes heterogeneity as a moderation mechanism. By framing domestic pressures of family and built environment as an interdependent system, we examine how the built environment moderates non-routine activity participation across family types to uncover the heterogeneous responses under the built environment improvement policy.

Methodology

We use one month of longitudinal human mobility data from Tokyo's 23 wards to construct a moderation-based model. Specifically, we employ an Ordinary Least Squares (OLS) regression framework with a rolling window strategy to capture behavioral variations over time. To mitigate issues of self-selection and individual preference, we integrate longitudinal individual-level data. The model incorporates interaction terms between sociodemographic characteristics and built environment variables to examine the conditional effects of the built environment across different family types.

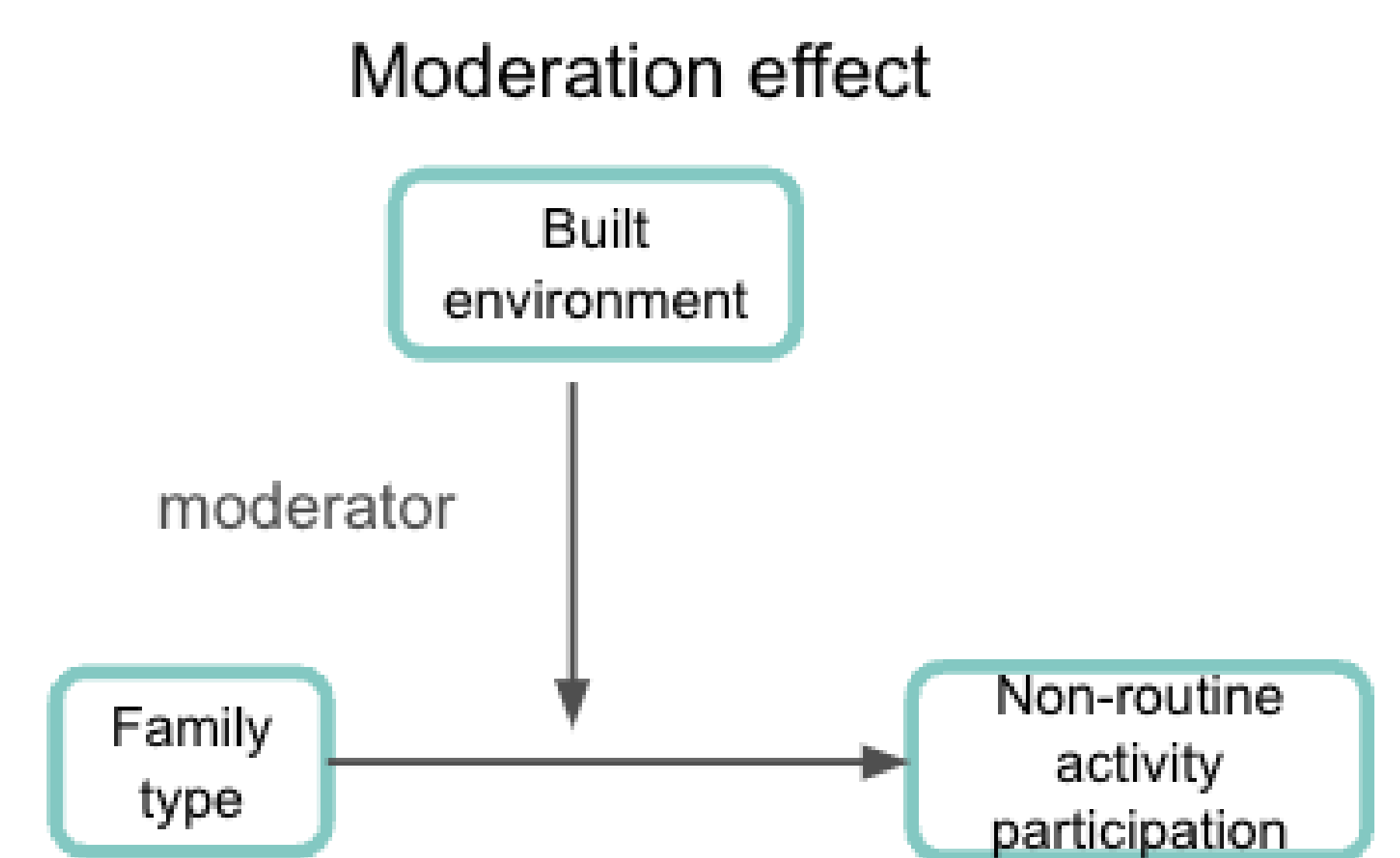


Fig. 1 moderation model

Result

Compared to females without children, females with children generally show a lower non-routine activity duration across most areas, particularly in central Tokyo and the outskirts of the 23 wards. However, in some mid-region areas, even mothers likely facing domestic constraints exhibit relatively stable levels of non-routine activity, such as Omotesando and central Meguro Ward which is known for their affluent residential communities.

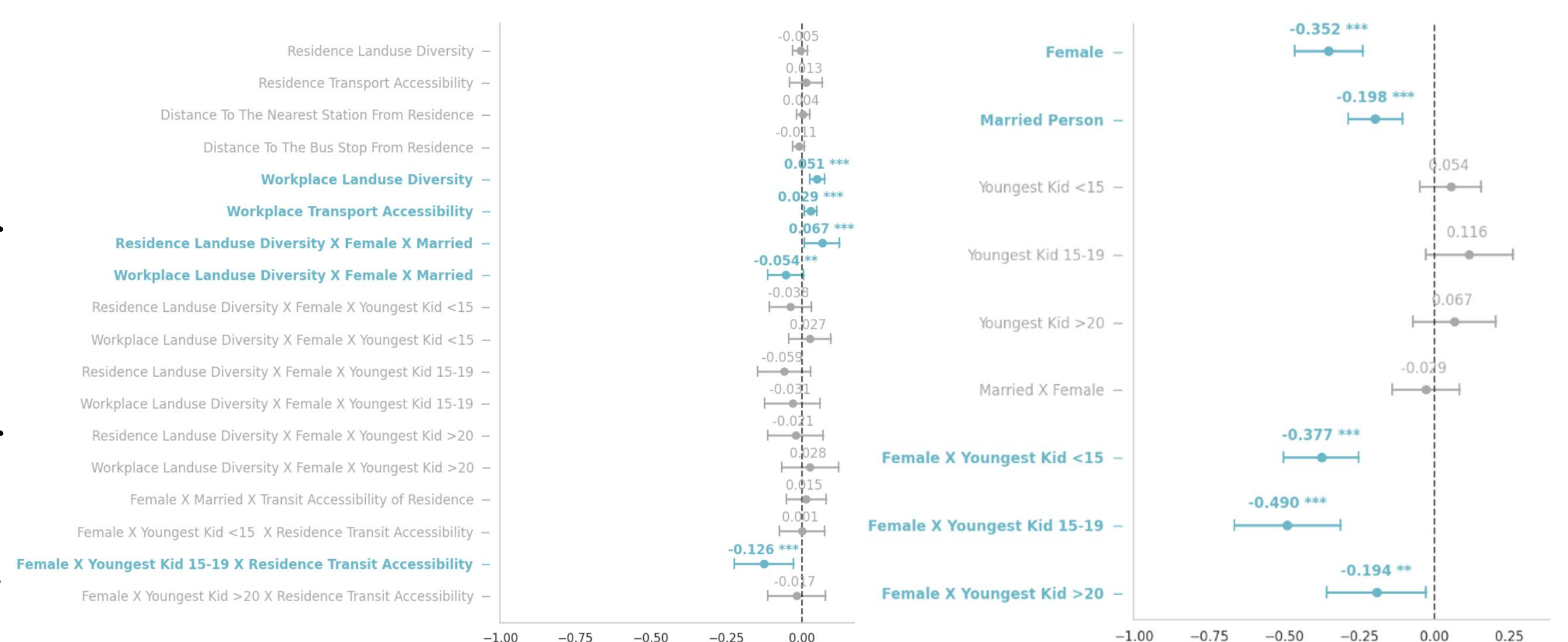
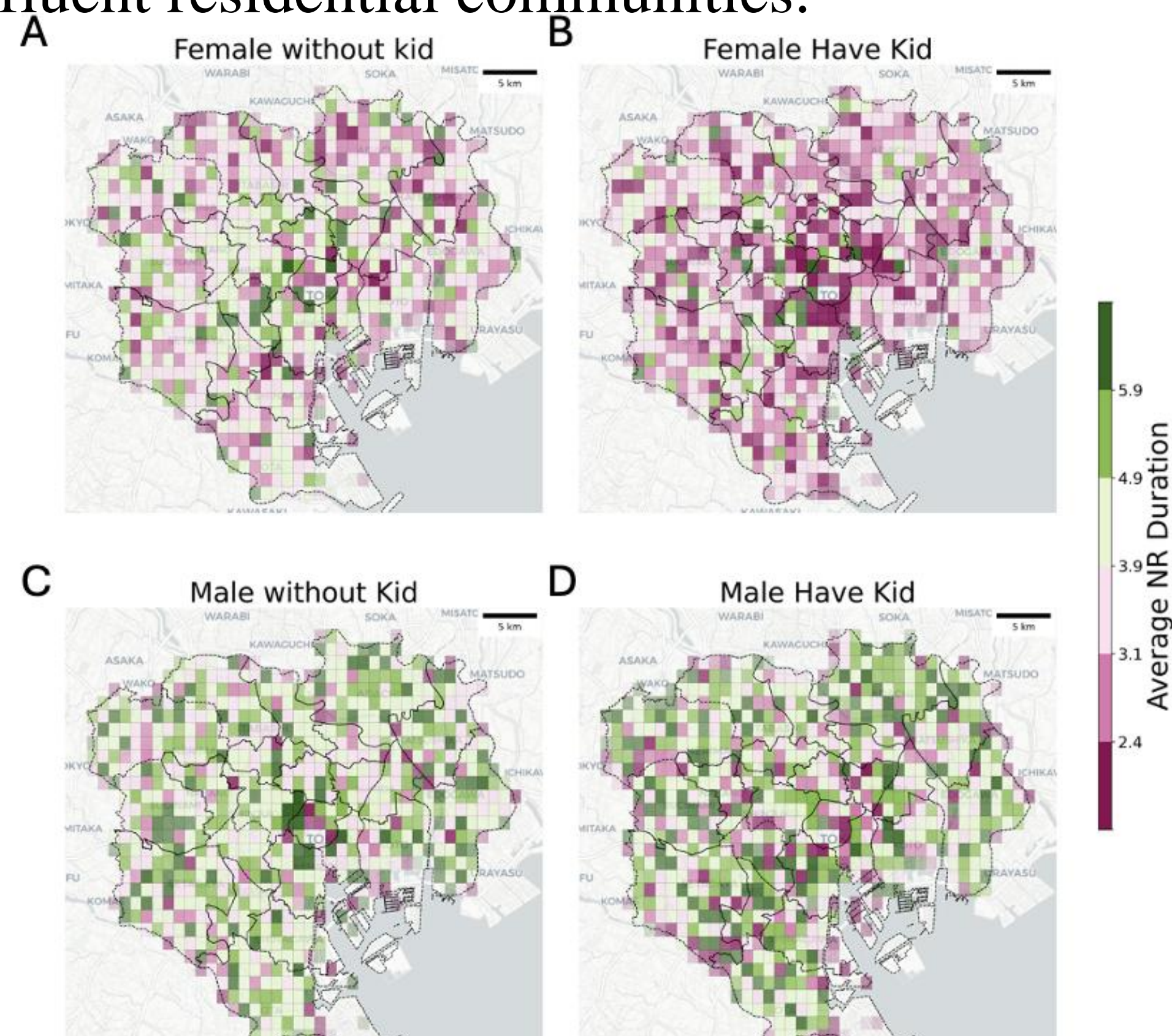


Fig. 3 moderation model result

Mothers consistently engage in fewer non-routine activities, and their constraints are further exacerbated by higher residential transit accessibility. For married women, the higher workplace land use diversity significantly further declines their non routine participation but higher residence land use diversity further mitigates the declining non routine participation trend they face. Our findings also reveal that built environment improvements elicit heterogeneous responses—alleviating constraints for some groups while intensifying them for others.

Conclusion

These findings highlight the importance of recognizing social roles based mobility constraint and a more nuanced approach to urban development.