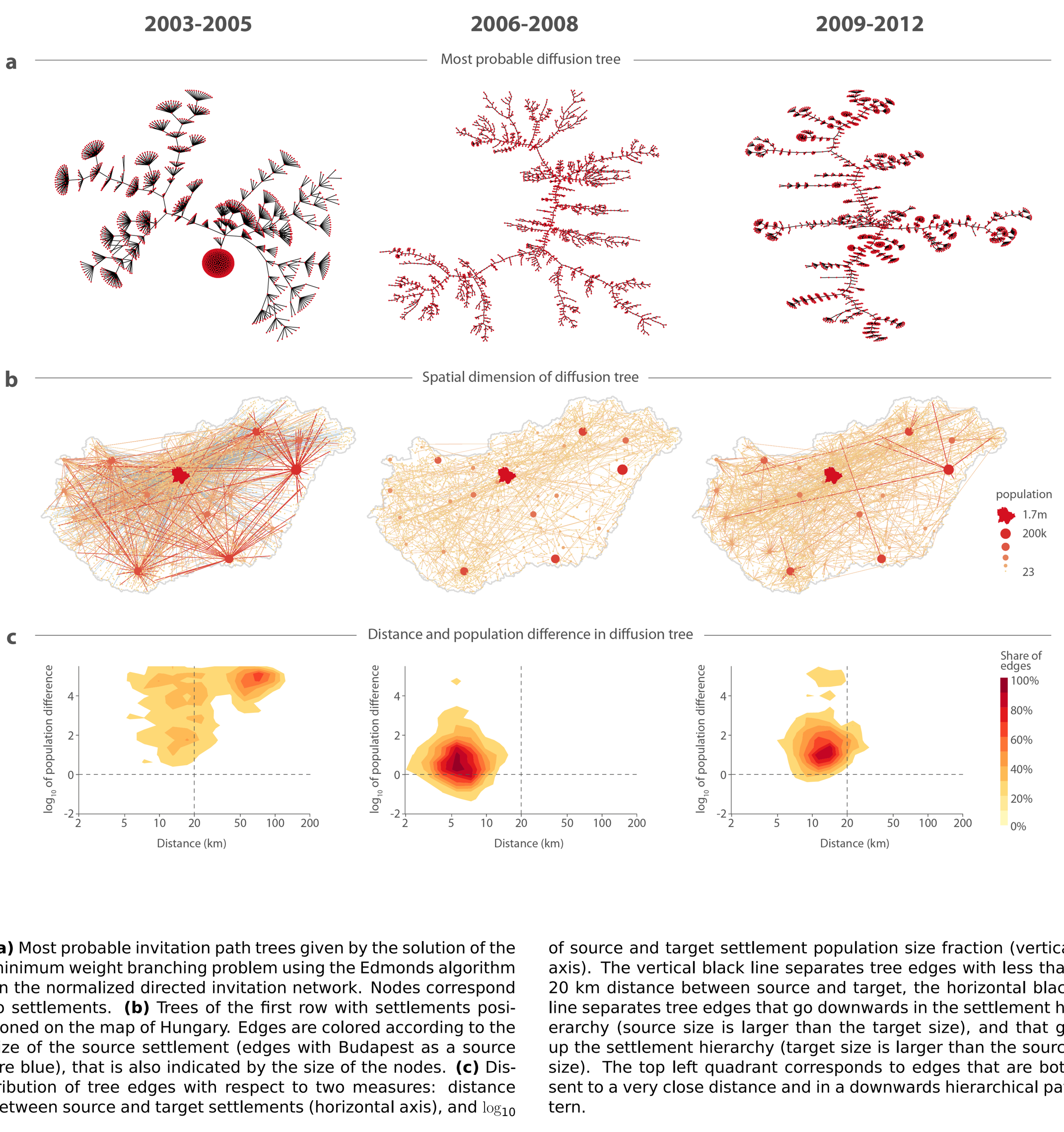
Urban hierarchy and spatial diffusion over the innovation life cycle

Eszter Bokányi[1,2,3], Martin Novák[1,4], Ákos Jakobi[5], Balázs Lengyel[1,2], Szabolcs Tóth–Zs.[1,2,6]

[1]ANET Lab, ELKH Centre for Economic and Regional Studies, Budapest
[2]NETI Lab, Corvinus University of Budapest
[3]POPNET Group, ILLC, University of Amsterdam
[4]ELKH Wigner Research Centre for Physics, Budapest
[5]Department for Regional Science, Eötvös Loránd University, Budapest
[6]BANDART Productions https://sabi.bandart.eu/

For decades, spatial diffusion has been argued to take place along the urban hierarchy. Yet, the role of geographical distance was difficult to identify in hierarchical diffusion due to missing data on spreading events. We exploit spatial patterns of individual invitations sent from registered users to new users over the entire life cycle of a Hungarian social media platform. We demonstrate that hierarchical diffusion overlaps with diffusion to close distances and that these factors co-evolve over the life cycle in the settlement-level normalized invitation network, that is a directed weighted network of time-evolving outgoing invitation probabilities.



(a) Most probable invitation path trees given by the solution of the minimum weight branching problem using the Edmonds algorithm on the normalized directed invitation network. Nodes correspond to settlements. **(b)** Trees of the first row with settlements positioned on the map of Hungary. Edges are colored according to the size of the source settlement (edges with Budapest as a source are blue), that is also indicated by the size of the nodes. **(c)** Distribution of tree edges with respect to two measures: distance between source and target settlements (horizontal axis), and $\log_{10}$ of source and target settlement population size fraction (vertical axis). The vertical black line separates tree edges with less than 20 km distance between source and target, the horizontal black line separates tree edges that go downwards in the settlement hierarchy (source size is larger than the target size), and that go up the settlement hierarchy (target size is larger than the source size). The top left quadrant corresponds to edges that are both sent to a very close distance and in a downwards hierarchical pattern.

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e.bokanyi@uva.nl

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