A spatial agent-based model of the UK housing market: understanding the economic roles of infrastructure

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Infrastructure systems are, in conjunction with the socio-economic environment in which they are embedded, prime examples of complex socio-technical systems. Whilst a growing number of empirical studies have addressed the relationship between infrastructure investment and economic growth, the mechanisms by which infrastructure influences economic activity are not well understood in quantitative terms. Part of the difficulty derives from the fact that infrastructure delivers services to businesses and society through networks, and thus any appraisal needs to take place at a system scale. Furthermore, infrastructure can have non-marginal economic effects, and the corresponding investments are often intended to promote structural change, innovation, and social well-being. Infrastructure systems therefore present well-known, but still unresolved, challenges from the perspective of economic appraisal.

In this contribution, we study some of the main channels and mechanisms by which infrastructure has an impact on the economy. In particular, we focus on its effect on housing markets. Housing is the largest asset class in the economy, as well as one of its main drivers: the dynamics of house prices has a direct impact on the balance sheets of banks, and thus on the availability of credit, as well as on household debt, and thus on consumption levels. At the same time, housing markets are strongly influenced by the rest of the economy. In particular, the geographical distribution of the demand for houses is, to a significant extent, driven by the availability of employment opportunities. Households are, indeed, confronted with a joint choice of employment and housing: they need to find a job corresponding to their skills and, simultaneously, search for a house that they can afford with the corresponding salary and within a feasible commuting distance from the referred employment. Transport infrastructure is essential for assessing this distance and, thus, plays a major role in determining the geographical distribution of the demand for housing. Simultaneously, it is precisely this spatial distribution of houses which determines the geographical structure of the demand for all infrastructure services, from solid waste to energy and water. Finally, as a consequence of constant improvements on the digital communications sector, different spatial distributions of houses and employments become feasible.

In order to model this complex relationship between the economy and infrastructure through the housing sector, we develop a spatial agent-based model of the housing market. In particular, we develop a district-based model, i.e., we define a discrete set of locations, each of them containing a non-spatial housing market model, and a set of couplings or commuting fluxes between those locations. The non-spatial model used in each of the districts (inspired by [1]) simulates a large pool of households with realistic life-cycles, inheritance of properties, buy-to-let investors, and it models the rental market in detail. This approach allows us to tackle simultaneously two types of heterogeneities: on the one hand, the internal heterogeneity of each district's market, where we model the individual behaviour and interactions of first-time buyers, home owners, buy-to-let investors, and renters; and, on the other hand, the geographical heterogeneity due to different agglomeration mechanisms.

As a case study, and as a result of an ongoing collaboration with the Bank of England, we focus on data about the UK for the purposes of model calibration and validation. In particular, the model is calibrated against a large set of microdata from household surveys and housing market data sources such as the Financial Conduct Authoritys (FCA) loan-level Product Sales Data (PSD) and the When-Fresh/Zoopla data on rental listings, as well as confidential data from the Bank of England. Once these microdata sources have been used to fine-tune households individual characteristics and behaviours (e.g. the joint income and age distribution), a macro-calibration is performed to ensure consistency with different economic aggregates and housing market core indicators.

[1] Rafa Baptista, J. Doyne Farmer, Marc Hinterschweiger, Katie Low, Daniel Tang, and Arzu Uluc, Macroprudential policy in an agent-based model of the UK housing market, Staff Working Paper **619** (2016).