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Initial Results from an Agent-Based Simulation of Housing in Urban Beirut

Extended Abstract

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ABSTRACT

The motivation for this extended abstract is to develop an agent-based model (ABM) to capture the existence of migrant and refugee flows, and to explore their effects on urban dynamics. We leverage an extant agent-based model founded on the rent-gap theory, as a lens to study the effect of sizeable refugee migration upon a capital city in West Asia. In order to calibrate and validate the simulation model, we construct indices for housing prices and other factors. Results from the model show the impact of migration shock on the housing market, and identify the relative efficacy of housing intervention policies. Our work progresses towards a tool for policy makers asking what-if questions about the urban environment in the context of migration.

KEYWORDS

rent-gap theory; migration; agent-based modelling; Lebanon

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1 INTRODUCTION

Previous works constructed a micro-level ABM, derived from the *rent-gap theory* (RGT)—an economic hypotheses on the dynamics of investment in housing—in an effort to model the economic mechanics of property investment along with their effects on the cultural and social diversity of urban areas. Picascia [4], whose approach we follow, examined the price dynamics triggered by different levels of capital flowing in a city and the patterns of spatial inequality that may emerge. He developed a model of housing regeneration, and applied it to a major European city [3]. We went on to extend the ABM to include refugee migration, but only in the form of an abstract, stylized model [5].

Our current work goes beyond previous models, grounding our work in the city of Beirut, Lebanon (Fig. 1). This is a densely-populated capital of a middle-income West Asian country which, according to official estimates [1, 6], has experienced a refugee influx of approaching 50% of its population in the period 2012–2016, causing extreme pressure on housing and social fabric [1, 2]. We build the first (to our knowledge) validated ABM of metropolitan Beirut using data for population, housing prices, and property conditions. Our contribution includes devising principled indices for these factors and incorporating UNHCR-supplied data for refugees. Our model, implemented in the ABM platform NetLogo [7], is adept to investigate the possible societal consequences and economic indicators of migration, being specifically designed to explore the interrelation of urban economic and cultural dynamics. Results of the simulation, briefly discussed here, exhibit how sizeable migration of low income populations into a city impacts prices, slum locations, population density, and segregation.

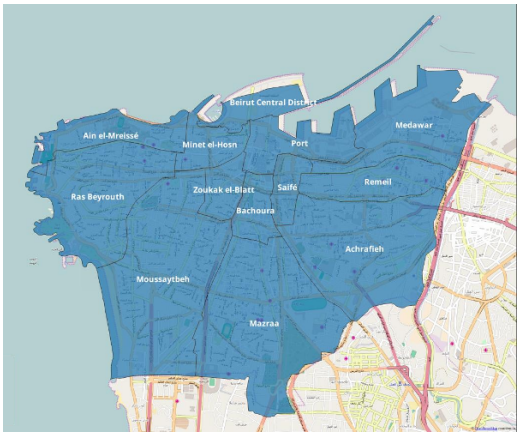

Figure 1: Metropolitan Beirut.

2 SIMULATION MODEL

Our agent-based model simulates urban dynamics at the level of an entire city. The entities represented in the model are: (1) individual locations (residential properties), defined by their market value, repair state, and population; (2) individual agents that represent households, characterised by an income, mobility propensity, and cultural configuration; and (3) economic forces, represented principally in the form of exogenous 'capital' level, aiming at profiting from redevelopment/restoration of residential locations. The model in abstract form is described in our previous paper [5].

There are multiple challenges in modelling Beirut using actual data. Lebanon has no official census since 1932, and in addition many of the current refugees are not legally resident. Reliable geo-referenced data relating to the variables relevant in the model are non-existent or not easily accessible. Prior to 2017, there is no

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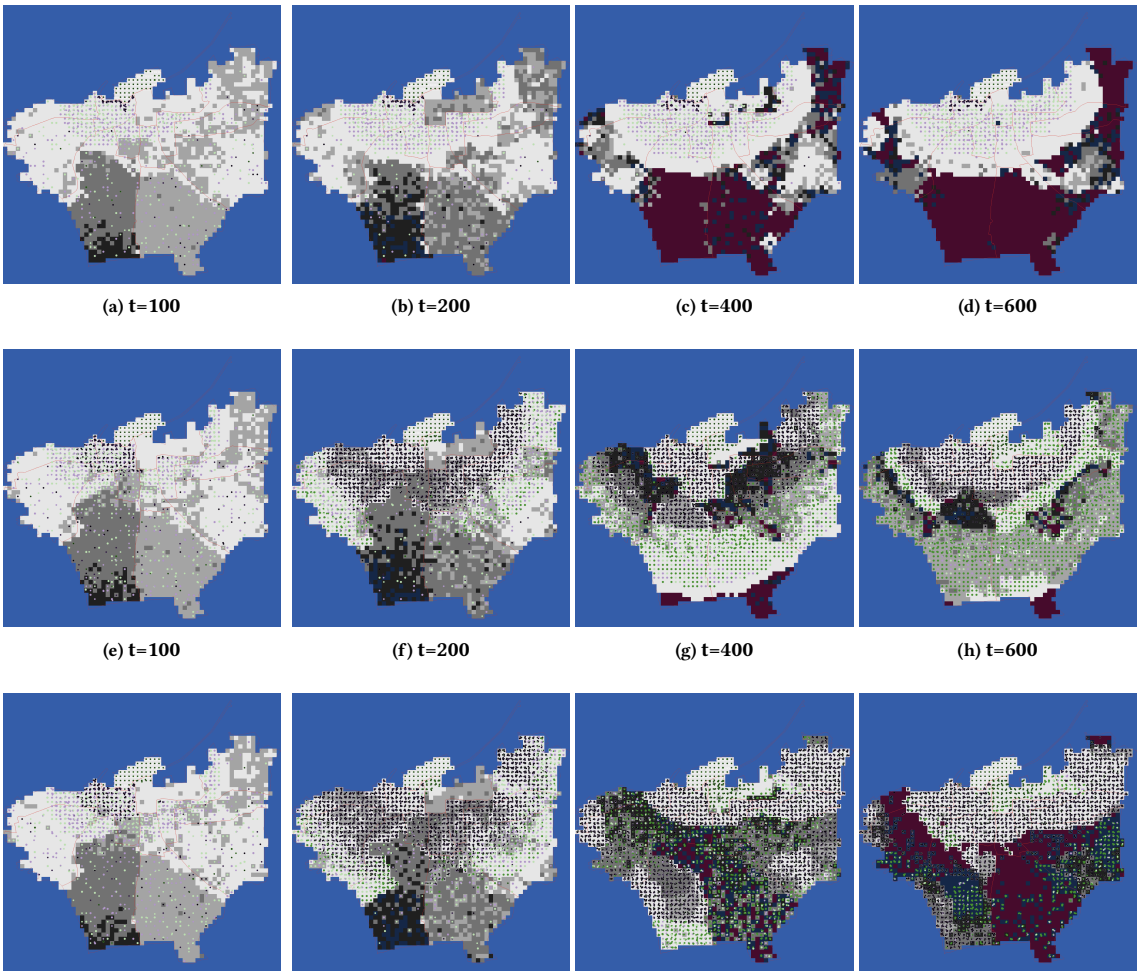

(a) t=100 (b) t=200 (c) t=400 (d) t=600

(e) t=100 (f) t=200 (g) t=400 (h) t=600

(i) t=100 (j) t=200 (k) t=400 (l) t=600

Figure 2: City locations over time. Top row = no refugees, middle row = refugee influx between $t = 90$ and $t = 180$, bottom row = ongoing refugee influx from $t = 90$. Slum locations are dark blue, uninhabitable locations are dark purple.

official, published data about housing prices—neither for Beirut nor indeed for the country—leaving only estimates.

While open-source GIS data proves adequate for cartographic modelling, and while there are a basket of population estimates that can be weighed for demographic modelling, in order to obtain economic data we developed and validated a multi-variate time series econometric analysis. Further, in order to obtain data about the current maintenance condition of residential housing in Beirut, we undertook a property survey in summer 2017.

3 SUMMARY RESULTS

Fig. 2 shows example evolution of prices and population over time, in three scenarios. The simulated period corresponds to five years, starting in 2012. The top row shows a baseline scenario without refugees, the middle row shows limited but sizeable refugee influx, and the bottom row shows an ongoing influx.

Outcomes from the model exhibit that refugees have some surprising impacts on prices and slum locations, as well as impacting population density. Their presence can cause price spikes and invigorate or dampen the natural economic cycle, which continues nonetheless with waves of decay and regeneration. We observe a further interesting effect depending on the capital in the economy and the rate of mobility, whereupon excessive shock of refugees—and in particular ongoing migration to the city—can render large sections of quarters uninhabitable, causing parts of both refugee and non-refugee populations to emigrate.

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