



A probabilistic model of residential urban development along the French Atlantic coast between 1968 and 2008



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ABSTRACT

In most developed countries, the acceleration of coastal urbanization during the second half of the twentieth century has gradually resulted in a concentration of residential housing and associated infrastructure and facilities along a narrow coastal strip, along with various environmental, functional and social impacts. This has led certain countries, such as France, to adopt protection legislation with respect to their coastlines. However, while numerous studies describe and analyse the consequences of urbanization on the coastal environment, few of them examine the influence of the coast on urbanization. This paper focuses on the residential development process, considering the coastline as both a pull factor on account of its amenities, and as a constraint due to the legislation put in place to protect it. Our study aims to build a database describing the factors that influence the probability of housing development on vacant land and to analyse the spatiotemporal evolution through a logistic regression modelling approach. While controlling the factors usually mentioned in the scientific literature on urban sprawl and suburbanization, this method is also able to isolate the effects of coastal attractiveness, taking laws and bylaws regulating urbanization in such areas into consideration. It shows in particular that, since the early 2000s, the gradual implementation of a land planning framework specific to the coastal zone has led to improved regulation of housing development in the study area. Throughout the country, the French Coastal Law limited available land for housing development, particularly in coastal areas, by enforcing building restrictions in accordance with conservation principles. The paper concludes with potential improvements to our models, e.g. the integration of local economic factors, such as land costs or changes in taxation, all of which influence housing choices and could potentially regulate suburbanization.

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1. Introduction

Throughout history, human settlements have grown and developed in coastal areas for practical reasons that are mainly related to their natural resources and strategic location (Hudson, 1996). In most developed countries, it was only in the eighteenth century that coastal areas became associated with notions of lifestyle and leisure (Mullins, 1991), gradually leading to a concentration of urbanization and associated infrastructure and facilities along a narrow coastal strip.

Outside of port towns and coastal villages, other specific forms of urbanization related to the development of tourism thus emerged, including mansions and seaside resorts from different periods.

These were followed by more mundane forms related to the proliferation of residential housing, either individual or within a planned framework, such as housing estates. Indeed, with the increasing mobility of households, holiday and retirement resorts have emerged in the same way: as settlements resulting from suburbanization and motivated by expectations of a better quality of life than in town centres, all of which amplify pull factors.

Population concentration linked to the attraction of the coast is observed at continental, national and regional scales (Small and Nicholls, 2003), whereas at the local level, it is mostly observed in places that were not previously used for other urban activities, such as ports and sea-related industries. The effects of this coastal population concentration and related developments are well known (Ewing, 1994; Couch et al., 2007), including competition for land, and lead to social exclusion and increased exposure to erosion and flooding risks (Hunt and Watkiss, 2011; Cooper and Lemckert, 2012). This has led some countries (e.g. Spain, Australia or various

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US states) to adopt legislation with respect to their coastlines (Orsi, 1996; Gurran et al., 2007; Negro et al., 2014) in an attempt to preserve natural areas for the sake of sustainable development and integrated coastal zone management (ICZM) (Cendrero, 1989; Ballinger et al., 1994; Cicin-Sain and Knecht, 1998).

However, while numerous studies describe and analyse the consequences of urbanization on the coastal environment (Burak et al., 2004; Romano and Zullo, 2014), few of them examine the opposite effect, i.e. the influence of the coast on urbanization. Nevertheless, understanding the coastal effect is instrumental to the enhancement of geographical analysis and forecasts (e.g. land use simulation) for urban and regional planning that seeks to balance the development and conservation of scarce and fragile coastal environments. This paper focuses on the residential development process, considering the coastline as both a pull factor on account of its amenities, and as a constraint due to the legislation implemented to protect it. Our study is thus based on two questions. Among local pull factors that influence the probability of residential development on vacant land: (1) is it possible to isolate a coastal effect related to its appeal taking into account specific measures adopted to regulate urbanization in such areas? and (2) have these factors changed over recent decades and how are they related to plot size and land availability?

Historical land use data at the plot level was used to develop a case study in a French context for *Pays de Brest* in Brittany. Based on a short literature review of the main determinants and the modelling of housing development, Section 2 presents our approach to addressing the research questions. Section 3 describes the context, study site and available data. Section 4 presents the methodology. Sections 5 and 6 show and discuss the results respectively, leading to the conclusion in Section 7.

2. Determinants of residential development

The apparent lack of spatial organization caused by the spread of housing developments can sometimes give the impression that this process is largely spontaneous, guided only by the supply of land and the demand for housing, reflecting the view put forward by Vallega (2001) arguing that urban planning does not apply to suburban areas. However, the literature on land use and land cover changes (Agarwal et al., 2002; Lambin and Geist, 2006; Torrens, 2008; Mas et al., 2014), on spatio-temporal changes in property values (Grether and Mieszkowski, 1974; Can, 1992; Irwin and Wrenn, 2014) and on residential development (Carrion-Flores and Irwin, 2004), shows that the development process involves a combination of factors, partly theorized, and that it can be modelled.

2.1. The main local influencing factors of residential development

Urbanization is based on the interaction between households and amenities that promotes proximity and accessibility concepts as central tenets of the housing development process.

Workplace distribution is one of the major factors: jobs are often concentrated in nodes, including city centres, and, more recently, within sub-centres, business parks and industrial zones, which results in a polycentric organization (Anderson and Bogart, 2001). Besides employment, facilities (commercial, educational, leisure or health) are other attractive/necessary elements for households (Des Rosiers et al., 1996). In accordance with bid rent theory (Alonso, 1964), access to these central places can be calculated to verify their polarizing role (Hansen, 1959; Dubin and Sung, 1987). This depends on the configuration and connectivity of transport networks, and, more generally, urban form. Their inclusion in the modelling process is thus based on the computation of accessibility

(Geurs and van Wee, 2004; Thériault et al., 2005; Kwan and Weber, 2008). Access to amenities acts as a pull factor towards urban centres. However, scarcity of available land increases competition among potential users and generates a premium (location rent) that internalizes land cost, leading to a push factor towards the periphery for households (and businesses) that cannot or do not wish to pay for centrality. These regional economic factors yield urban sprawl (Harvey and Clark, 1965), which has significant implications for traffic, infrastructure and transportation costs.

At the local level, influencing factors include the attributes of available plots (specifically plot size, slope, exposure and view) and either positive or negative associated local externalities. Additionally, proximity to amenities such as transport infrastructure (e.g. highways and airports), facilities and industrial activities can generate noise and pollution (including risk exposure) that exert a push effect on housing development (Hunt and Watkiss, 2011). In contrast, households make their housing choices based on the appeal of landscapes and environmental amenities, and, more generally, the quality of the environment (Benson et al., 1998; Luttik, 2000; Kestens et al., 2004). These choices can be decisive to the extent that they give rise to genuine organization or even spatial segregation, as can be seen along many stretches of coastline (Vallega, 2001).

Additionally, urban planning tools and bylaws are usually determined to control the unwanted knock-on effects of housing development. Indeed, in countries where urban planning legislation is implemented, it can be very powerful in the regulation of evolving urban forms, either by promoting certain types of facilities and development, or by being restrictive when it comes to environmental protection (Carrion-Flores and Irwin, 2004; Munroe et al., 2005; Onsted and Chowdhury, 2014).

2.2. How these factors can be integrated into a housing development model

In the housing development literature, modelling can pursue two complementary goals:

- To shed light on and/or assess its effects on the evolution of urban forms (Dietzel et al., 2005), the social structure of towns and neighbourhoods (e.g. segregation, spatial mismatch, gentrification) (Kestens et al., 2005), the consumption of agricultural land (Levia and Page, 2000), the cost of land (Abelairas-Etxebarria and Astorkiza, 2012), or the environment (Vimal et al., 2012).
- To assess the influence of different factors on residential development: the setting up of new services or infrastructure (Dubé et al., 2013), the implementation of regulations and urban planning tools (Newburn and Berck, 2006), the factors behind urban sprawl (Carrion-Flores and Irwin, 2004), the proximity to open spaces, landscapes, and environmental amenities.

For this article, the purpose of modelling is to analyse the marginal contribution of specific and location attributes of available land leading to residential development, and to study their evolution in both space and time. Consequently, our approach is mostly empirical and statistical, while the retained factors are identified through previous research and constrained by data availability. Regression models are highly relevant (Kirk et al., 2011; Kolb et al., 2013; Wang et al., 2013) for such purposes because they enable the testing of each variable's specific contribution to the variation of the modelled phenomenon, while controlling for inter-variable interactions. However, to secure relevant results, due care should be taken to avoid pitfalls, such as multicollinearity, heteroskedasticity, autocorrelation and misspecification.

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