Ocean & Coastal Management 101 (2014) 89–101

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Coastal congestion: Simulating port expansion and land use change under zero-sum conditions

Daniel Felsenstein*, Michal Lichter, Eyal Ashbel

Department of Geography, Hebrew University of Jerusalem, Israel

ARTICLE INFO

Article history:
Available online 27 August 2014

ABSTRACT

This paper examines the displacement effects associated with new land use development in a congested coastal area. A land use micro-simulation model (UrbanSim) and statistical estimation are used to identify the expected future land use impacts arising from the proposed expansion of the Port of Haifa. Maximum and minimum development scenarios are simulated and compared to baseline (business-as-usual) conditions. Simulation outputs refer to future population, employment, residential and non-residential construction for the city of Haifa and its metropolitan area untill the year 2038. A key finding relates to the spatial substitution effects of additional non-residential floor space on residential development throughout the Haifa region. This highlights the zero sum effects of land use change under conditions of congestion. The challenge of efficiently using limited land use resources and balancing development across many competing uses and stakeholders, is stressed.

1. Introduction

Coastal development highlights the challenges of interfacing marine and terrestrial environments. Nowhere is this more acute than in the case of port expansion. Ports are inherently anthropogenic creations that extend mainland functions into the oceans. Coastal zones are intensely developed areas housing potentially conflicting land uses. Port land use competes with residential, industrial and recreational uses for access to finite shoreline space. The port is both endogenous and exogenous to this competitive process. On the one hand, it is invariably the cause of the demand for coastal land, spawning space-intensive economic development in its hinterland. On the other hand, its growth rate is influenced by the physical and socio-economic environment in which it develops.

Port expansion is an especially contentious land use issue in coastal areas. Port facilities are large scale infrastructural projects with clear economic and environmental consequences. The expansion of port facilities is also locationally inelastic. It inevitably incurs zero-sum costs on the one hand and is inherently limited in terms of alternatives, on the other. However, very little is known about the various ripple-through effects of this infrastructure growth on the urban fabric in its immediate hinterland. This forms a major motivation for this paper. Port hinterlands have been examined in relation to their role in the terminalization of ports (Wan et al., 2013) and their regionalization (Notteboom and Rodrigue, 2005). Surprisingly, rather less attention has been paid to the urban hinterland that invariably sustains the port. Port development therefore cannot be analyzed in isolation of urban development.

We use an integrated land use-transportation model (UrbanSim) to forecast coastal land use change under two alternative expansion programs for the Israeli port of Haifa for the year 2038. The interactions between multiple agents of land use change (households, workers, developers, government) are simulated and the feedback loops between their behavior and land use are explicitly modeled. Conventionally, we assume that agent behavior is motivated by standard principles of utility maximization and risk aversion. We are particularly interested in observing how a disturbance in coastal land use (port expansion) displaces other land uses such as residential development within the wider port hinterland and the region. This spatial spillover effect can be captured by the simulation model where location choices (agent behavior) and land use dynamics (amount of construction, value of units to be built etc) are captured simultaneously and adjusted dynamically.

Due to the intense competition for land along the crowded Israeli shoreline and the strategic importance of port facilities for international trade in a small, open but geo-politically land-locked economy, optimal use of limited coastal land resources is of primary importance. In terms of coastal zone management, this study

* Corresponding author.
E-mail address: msdfels@mscc.huji.ac.il (D. Felsenstein).

http://dx.doi.org/10.1016/j.ocecoaman.2014.08.001
0964-5691/

highlights the challenge of efficiently using limited resources and balancing development across many competing uses and many stakeholders. Adding the congestion along the Israeli coastline to this goal results in an inevitable zero-sum effect whereby any development is at the expense of some other development. There is no low-cost or costless route to coastal land use change.

The paper proceeds as follows. We review the literature relating to the land use implications of port expansion in Section 2. Particular attention is paid to the changing role of seaports and their implications for coastal management. Section 3 provides the context of the study. The physical setting and socio-economic composition of the area are described. Additionally the institutional context of port expansion in the Haifa region is charted as coastal development cannot be treated in oblivion of the political processes operating in the area. The fourth section provides a transparent description of the analytic model used in this study. This highlights the efficacy of using UrbanSim for simulating coastal land use change. Section 5 presents the scenarios and the motivation for their formulation. Simulation outputs are presented in Section 6 where two development scenarios are compared with a baseline (business as usual scenario). These results underscore the displacement effects associated with port development. We show that non-residential development has an inevitable substitution impact on residential development given the crowded zero sum conditions along the coast. Finally, we conclude with some implications for coastal zone management arising from the analysis.

2. Literature review

Seaports are more than just trans-shipment points. Historically, ports have been the nuclei around which urban development has taken place and despite their changing functions, they have retained that catalytic role to this very day. However, while in the past ports served as a bridge between the seaward foreland and the landward hinterland, today ports are conceived as nodes in global logistics networks or junctions in international commodity supply chains (Robinson, 2002; Rodrigue and Notteboom, 2010). The hinterland dynamics related to ports, of which land use change is a component, have been coined 'port regionalization' (Notteboom and Rodrigue, 2005). This concept expresses the new functions and morphology of ports brought about by containerization, inland terminals and supply chain management. According to this view, port regionalization is exposed to two forces. The first is globalization that relates to the role of the port in relation to other (port) nodes with which it is connected. This gives rise to competition, increasing mechanization and internal scale economies. The second force is that of local constraints. These relate directly to land use and negative externalities such as noise, pollution and road congestion. When these constraints are severe, the port loses its role as a coastal gateway and activities such as freight, handling and storage that used to be coastal land uses transfer to the port hinterland.

This change in function, operation and ultimately location, has generated a call for a re-evaluation of the role of ports as purely coastal land uses (Oliviere and Slack, 2006). It is argued that ports are no longer just 'spaces'. They are not simply forms of transportation infrastructure that happen to be coastal and with some unique characteristics derived from the land–sea interface. Thus, according to this view, the spatial analysis of port development (which includes land use simulation) does not go far enough. Ports, so the argument goes, are also 'places' and should be investigated as such. This means looking at the governance and institutional contexts in which they operate and the various interests involved in their expansion. The problem with this argument is that while it might offer insights into the way ports currently operate, it has very little to offer in terms of the future dynamics of port development and the way they impact on land use change. Additionally, it points to a potential problem of identification. If political and institutional factors are most acute in those port contexts where expansion is intense in the first place, the causal effect of governance factors on port expansion will not be identified. When the current political-institutional constellation changes and yet the port continues to expand, a new (ad hoc) explanation will need to be found that is independent of the outcome.

This is closely related to the theoretical interest in the question of why do port cities succeed way after their initial port-related advantages such as accessibility and low bridging points, become redundant? The answer clearly seems to be in the self-reinforcing agglomerative tendencies that they generate. Using the principles of the New Economic Geography (NEG), Fujita and Mori (1996) illustrate how the neo-classical port city model grounded in constant returns and comparative advantage is insufficient for explaining port city growth after the port function ceases to be important. Instead they offer an explanation in which urban port growth emerges endogenously through the agglomeration forces generated by increasing returns and transportation costs. This growth generates a lock-in effect that continues after the disappearance of the initial port-based advantages (access to water etc).

A further important insight grounded in the port-as-agglomeration view, is that while ports, like cities, are part of a network and ports link countries together just as cities do, there is also a synergetic relationship between port activity and local/regional growth. The agglomeration tendencies around ports can result in polarized urban/regional development. Ports are an inherent part of the trade (transportation) costs that lie at the heart of the NEG. High transportation costs create spatial equity by allowing economic activity to disperse. Low transportation costs generate core-periphery inequalities and agglomeration. Ports lower transportation costs and historically have been 'natural' centers of economic activity, often at the expense of other nearby centers. Port development would therefore seem to be a zero sum game in terms of economic activity.

The same may also be true in terms of land use. Huang et al. (2011) have noted that while the multiple interests involved in port development (communications, infrastructure, storage, power, engineering etc) all look to maximize the internal benefits of port expansion, the public interest calls for maximizing external benefits. This includes minimizing traffic bottlenecks and congestion around ports (Wan et al., 2013), reducing negative externalities such as pollution, visual blight and the by-products of land reclamation (Saz-Salazar and García-Menéndez, 2007; Luo and Yip, 2013) and regulating land use (Hansen, 2007, 2011). The hinterland effects of a seaport can be quite considerable. Notteboom (2004) notes that that inland logistics account for 40–80% of all container shipping costs. Wan et al. (2013) have estimated that increasing road congestion around a port by 1% can lead to a reduction in port throughput and hinterland activity by 0.9–2.48%. Thus ports and their hinterlands are heavily inter-connected.

While the land use implications of port expansion have not been directly addressed in the literature, there have been some attempts at simulating the effect of exogenous change (invariably climate-induced) on coastal land use. Hansen (2007, 2010) for example, examines the impact of two coastal flooding scenarios using a cellular automata (CA) driven simulation model. In this model, decision rules govern the mechanical movement of the cell occupants and the probability transitions between different states. The model distinguishes between active land uses such as residential and industrial uses, passive uses such as open space and static land use in which he clusters seaports, airports, waste purification sites