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Conceptualizing freight generation for transport and land use planning: A review and synthesis of the literature

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ABSTRACT

Freight generation and movement patterns are not well understood by planners and policy-makers tasked with making complex strategic land use and transport planning decisions. In the absence of detailed planning evidence, they may rely on scant or anecdotal data, extrapolated and presented through complex quantitative models. Unfortunately, predictive model outputs can fail to accurately match observed outcomes, and such models cannot predict complex long-term phenomena which may transformatively disrupt freight production and movement patterns.

Through a review of the literature, we apply Porter's Diamond Model of Competitive Advantage (Porter 1990) to develop a novel conceptual framework for freight generation. We illustrate how emerging themes and new evidence of relevant economic, environmental, social, and governmental factors can be meaningfully structured within this conceptual framework. By compiling recent evidence of spatio-temporal complexity from the literature, we highlight the utility of such a framework in assisting planners and decision-makers to incorporate a wider set of freight generation factors – particularly demand factors, land use relocation effects, shifting firm strategies, and emerging transport technologies – in the practices of understanding, modeling, planning, and managing urban freight. Application of the framework should assist in ensuring that significant factors and phenomena are not ignored in critical planning decisions, encourage the input of a more diverse set of planning expertise at the policy-making table, and throw renewed emphasis on potential qualitative and mixed-methods freight case study research.

1. Introduction

Almost all human activity depends on the movement of goods. Within cities, freight movement patterns are much more complex than for passenger transport, as freight movement involves interactions between firms and destinations at differing temporal scales along the process of production (Allen et al., 2012a; Woudsma et al., 2008; D'este, 2007). There is limited research and understanding of the spatial and temporal nature of goods movements within cities (Giuliano et al., 2017). Freight transport policy problems transcend local and regional planning jurisdiction boundaries, and local policy settings can easily exert effects across regional areas (Jakubicek and Woudsma, 2011; Pellegram, 2001). Those tasked with urban policy design and implementation frequently lack a detailed picture of the complex factors and interactions which influence freight movements (Ballantyne and Lindholm, 2014). Instead they may rely on the use of quantitative models. Many of these freight models are based upon passenger trip demand prediction models (Holguín-Veras et al., 2012; Joubert and Axhausen, 2011; Taylor and Button, 1999) which may lead to significant error in traffic forecasting outputs. Consistently, though, the ongoing visibility and concentrated impacts of freight transportation on the ground tend to hold them to the fore of policy attention (Cui et al., 2015).

Critically, "freight" encapsulates a multiplicity of movement types, including bulk materials transport, freight couriers, consumers moving goods, commercial vehicles, and waste management services (Ellison et al., 2017). Thus, measuring freight generation patterns – much less attempting to model and forecast them – is an extremely difficult endeavor (Woudsma, 2001). While quantifying aggregate inter-city freight transport is more straightforward, understanding the origin, destination and purpose of freight movements within an urban area is considerably more challenging (Dablanc et al., 2013; Woudsma, 2001). While much quantitative research has aimed to identify aggregate trip generation for almost all land use categories (Institute of Transportation Engineers, 2012), much less attention has focused on understanding behavior of freight generation agents (Sánchez-Díaz, 2016). Vehicle

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and trip purpose type are significant for policy-makers seeking to address specific freight transportation problems within cities, such as peak period congestion, noise impacts, or other policy issues. A number of empirical survey methods have been applied for the purpose of better understanding freight type and purpose (Allen et al., 2012b), but resource requirements tend to limit scale or scope. In light of these problems, freight generation models have long been used as a source of supporting evidence for urban freight policy-making processes.

At their most basic level, transport models attempt to apply theories and data about travel behavior to predict demand and patterns of movement (Rasouli and Timmermans, 2011). Such models may be used to estimate aggregated demand of a region or area, based on land use averages, or they may seek to specially estimate freight generation at the micro firm-level, using highly specific models with a number of input variables (Holguín-Veras et al., 2017; Timmermans and Arentze, 2014). Such predictive models are fundamentally abstract, and disguise the full set of urban diversity and underlying phenomena which influence freight and freight trip generation. This problem becomes particularly evident in discrepancies between model predictions and empirical observations whenever generic trip generation models are tested in local contexts (Clifton et al., 2015). Research demonstrates the absence of homogeneity between instances of seemingly comparable firms (Greene and Kannan, 2011; Iding et al., 2002). These discrepancies may be partially attributed to the ecological fallacy, to which freight or transportation generation forecasting models are vulnerable. The ecological fallacy concerns thinking that phenomena observed in the aggregate is true for an individual within that group (Freedman, 1999). Falling foul of this fallacy, models frequently assume homogeneity within categories (Timmermans and Arentze, 2014). Land use categories – upon which models often depend - are themselves arbitrary constructs, vulnerable to fluidity and diversity of firm activity which they aim to characterize (Guttenberg, 1993). Only through local recalibration do some models begin to match field observations (Clifton et al., 2015), highlighting that while models are often touted as being predictive, they are fundamentally reactive, as they are recalibrated against new findings, events or phenomena as new inputs (Wegener, 2004).

Policy-makers may lack a detailed understanding of the complex interactions between land use, infrastructure and freight transport (Marsden et al., 2011), and use erroneous research conclusions to enact ineffective or harmful transportation policies (Holguín-Veras et al., 2017). For instance, Mullen and Marsden (2015) suggest that the use of transport models engenders a reliance on supply-side transport solutions, while other crucial outcomes, such as employment creation or redistribution, may be neglected. Crucially, the freight environment is highly variable and fundamentally influenced by a wide spectrum of stakeholders and governments. Governments typically provide infrastructure, and manage externalities associated with freight movements (Visser and Hassall, 2010). The externalities involved in the production and movement of goods have exerted strong influence on spatial policy since the Industrial Revolution, shaping the segregation of land uses within cities (Taylor, 1998). Industrial development patterns have generally become increasingly clustered and specialized in response to political and economic factors (Chhetri et al., 2014; Gulyani, 2001), further influencing urban movement patterns. Specifically, for instance, logistics firms have become particularly significant clusters, as they have relocated to cheap, distal peri-urban land (Cidell, 2010; Kumar et al., 2017), or low-amenity areas, such as around airports. In many post-industrial cities, the decline of railways and old inner-urban ports has coincided with immense structural changes in freight movement geography (Haywood, 1999). All the while, the cost of moving freight has steadily declined (Glaeser and Kohlhase, 2003), triggering new demand and activity patterns.

Through a review of international literature, we identify key challenges of planning for freight in cities. We draw together the findings from a broad set of authors, using Porter's Diamond Model of Competitive Advantage to develop a conceptual framework for integrating evidence and interdisciplinary knowledge relating to freight transport. Highlighting the entangled factors behind the problems faced by transport and land use policy-makers, Section 2 explores the gamut of factors which may impede the accuracy of freight trip generation modeling, based upon insights from research literature. We review the governance implications of relying upon such models to inform transport and spatial planning decisions in Section 3. In light of these issues, we expand Porter's Diamond Model (Porter, 1996) to related freight-specific factors in Section 4. In doing so, we synthesize a general framework of relevant considerations, of value for decision-makers aiming to address freight-related challenges. In the closing section of the paper, we propose future research directions for how such a framework might be further developed into a qualitative governance tool, a decision support system, a review device, or a quantitative model, mechanically reminiscent of those currently in use by transportation engineers.

1.1. Research approach

A systematic review was conducted of research papers on freight generation by land use categories. A general search for freight generation evidence from major online databases (Scopus, Google Scholar, Transportation Research Board, and Web of Science) was undertaken, supplemented by general internet searches, yielding 99 papers. Peer reviewed, institutional, and industry sources were included. Snowballing yielded a further ten papers. After a first round of review, potential gaps in the literature were further interrogated through targeted, land-use specific searching, resulting a further 20 papers being included for analysis. Following the review of all sources, a lack of a theoretical freight generation framework discussion within the academic literature was evident. Additional library searches and supplementary snowballing was undertaken to confirm the absence of an equivalent discussion. In all, more than 140 sources were reviewed by the authors in the development of this paper.

2. The limitations of models

Transport models seek to represent actual patterns which occur in cities, most usually to enable forward predictions. They may be aggregate, seeking to represent total movements within cities, or they may attempt to model the activities of individual agents (Næss, 2011), producing a more adaptable model which accounts for individual complexity. Taylor and Button (1999) illustrate a basic diversity of models types (Fig. 1).

The traditional four step model (attraction/generation, distribution, modal split, and route assignment) is commonly applied at aggregate level, and cannot account for individual stakeholder behavior (Joubert and Axhausen, 2011). They have several inherent limitations since they calculate flows in aggregate, can have conflicting sub-modules, and make coarse generalizations which do not replicate actual spatio-temporal dynamics (Taylor and Button, 1999). Accordingly, the current predominant trend in modeling for transport is disaggregation; that is, models are becoming more highly attuned to local and contextual factors (Wegener, 2011). Activity based models, which attempt to model greater diversity and different behavior of individuals and households, have been developed to supersede four-step models (Rasouli and Timmermans, 2011). A range of network-level prediction models have been developed (Giuliano et al., 2017), but these may be of limited use for sub-regional or local planning policy problems.

All transport models depend on fundamental assumptions, which extend even into the basic definition of concepts such as “transport.” For instance, transportation may be perceived simply as an industry or service which enables other industries (Chenery and Clark, 1959), the demand for which is thus directly derived from the scope of other human activities (Ortuzar and Willumsen, 2011). However, applied research reveals that transportation demands are highly elastic,

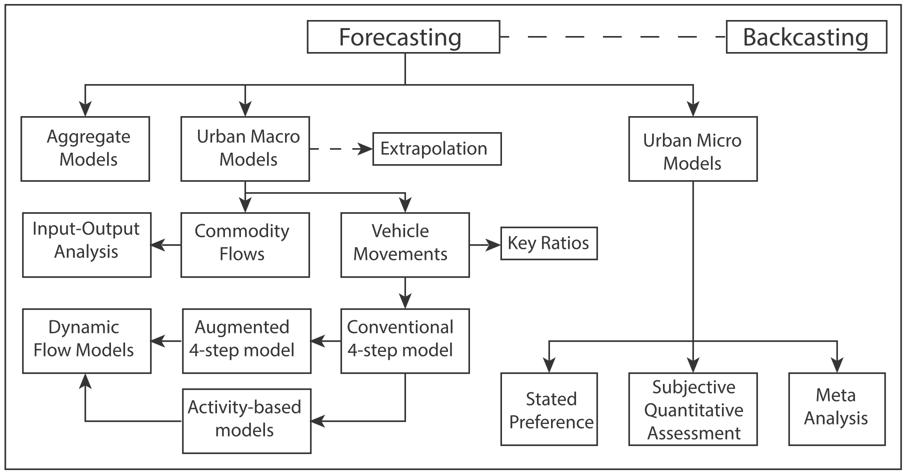

Fig. 1. Urban freight model types. Source: Taylor and Button (1999).

depending on the transportation options available (Dablanc et al., 2013; Holl, 2004a, 2004b, 2006). Falling freight costs have resulted in firms adopting completely different supply chains, production strategies, and business practices, in order to exploit resulting competitive opportunities (Glaeser and Kohlhase, 2003; Tavasszy et al., 2012).

2.1. Congestion dynamics

Congestion is pivotal to transport policy formation. Congestion is a risk factor which may vary the actual cost of moving freight (Muñuzuri et al., 2010; Woudsma, 2001). The traditional, rationalist concept of congestion is that it is a force which limits opportunity, and therefore stifles growth (Ortuzar and Willumsen, 2011). However, some evidence suggests that most firms will tolerate a degree of poor freight access if they are located in favorable urban locations which otherwise provide an effective location for their business (Grieco, 1994; Sweet, 2014). Evidence suggests that firms develop strategies (such as increased local stockholding or more specialized, high-margin production) where transport access is poor (Gulyani, 2001; Holl, 2004a). In congested cities, freight agents may even develop supply chains which involve non-normative modes, such as public transportation, or bicycles (Baindur and Macário, 2013; Arvidsson and Pazirandeh, 2017). Similar phenomena have become widely documented for passenger transport, with concepts such as Induced Demand and the Downs-Thompson Effect coming to the fore (Cervero, 2002; Hymel et al., 2010). We reason that at the heart of the tension between classical modern and postmodern theories of transport is the question of whether the interpretation of observable phenomena, such as congestion, should be objective, with one common interpretation, or contextually variable. The latter view has underpinned a strategic realignment away from meeting demand with supply, to placing limits on supply of transportation potential to achieve sustainability ends (te Brömmelstroet and Bertolini, 2008), particularly for passenger transport. Concurrently, global production patterns and land use structures within cities have adjusted to exploit land, labor and resource price differentials made more available by very low cost transportation (Hesse, 2004; Jakubicek and Woudsma, 2011).

Factors well beyond logistical capacity influence firm's choices to utilize and locate within major hub cities - service industry capacity, economic flexibility, the availability of labor and other city attributes make some hubs more attractive that others (Cui et al., 2015; Rodrigue and Hesse, 2007). Critical to understanding freight is the propensity for freight generating land uses to relocate in response to a myriad of factors (Jakubicek and Woudsma, 2011; Aljohani and Thompson, 2016; Holl, 2004b). Even if such triggering variables can be quantified, the location considerations of businesses are likely to follow a particular set of factors owing to complex individual contexts. Further, these meso-level phenomena may reduce the utility of older data - as geopolitical, technological and socio-economic trends continue to shift, simplistic transportation models cannot rapidly integrate this complexity. The cognitive simplifications needed to create an abstract model (and the models input parameters) to represent complex urban phenomena is inherently shaped by the modeler's normative context and personal world-view (Pas, 1990; Ralph and Delbosc, 2017), giving rise to models which are both limited by the perspective of their creator, and of the era and context in which they were made. Whilst the outputs models generate may be relatively simple and easily to interpret, attempting to understand the underlying mechanisms of the “black box” of sophisticated algorithmic models may engender additional confusion, or add layers of complexity which jumble the already complicated actual dynamics occurring within cities (te Brömmelstroet et al., 2017). Rasouli and Timmermans (2011) acknowledge the nature of complex social phenomena impacting transportation choices and resulting patterns, hypothesizing that additional complexity in evolutionary iterations of future models may be a means of representing these effects.

2.2. Land use input definitions

A key challenge of modeling research is applying observational data to refine, test, and calibrate models, particularly in different contexts (Jonsson et al., 2011). One critical impediment to more rapid refinement is the lack of a consistent classification system for land use types (Günay et al., 2016). While planners utilize land use classifications as a fundamental epistemological and functional basis for their profession (Guttenberg, 1993), there exists no consistent international land use classification system (Holguín-Veras et al., 2012). Land use definitions devised for transportation purposes often do not match existing administrative or business classification systems, necessitating time-consuming manual translation (Holguín-Veras et al., 2012); the lack of international interoperability between classifications is thus a significant barrier to research. Many mathematical transportation models assume highly basic land use types, which may be as abstract as a dichotomous household-business differentiation (Martínez, 2003). Such coarse classifications bear little resemblance to actual the urban milieu. However, even if their definitions were perfectly calibrated, land use types do not capture actual resulting levels of activity - uses can become dormant. Often, employment data is used as a coarse activity metric (Holguín-Veras et al., 2012), though the relationship between employment and freight generation does not hold true between different land use divisions (Holguín-Veras et al., 2011; Iding et al., 2002; Lindsey et al., 2014; Joubert and Axhausen, 2011).

Several basic problems impact upon the accuracy and usefulness of interpreting economic data for freight policy purposes. The "headquarter effect" often results in all logistical activity for a firm being attributed to an administrative address, rather than the actual location of activity (Jaller et al., 2015). Surveys of major road entry points into cities can reveal total inter-city road freight activity, but fail to capture intra-city freight (Swamy and Baindur, 2014). For this reason, heavy logistical flows which pass through easily identified entry points may receive research and policy attention (Holguín-Veras et al., 2012), compared to diffuse point-to-point trips which may take a multitude of potential routes through a road network. A key example of the illusiveness of some freight movements is that light vehicles used to make deliveries are freight vehicles (Ellison et al., 2017) which may be detected as cars by some sensors (Allen et al., 2012b).

2.3. Firm freight and trip generation

The generation of freight (that is, the production of goods or mass) does not necessarily result in comparable freight *trip* generation (Holguín-Veras et al., 2011). Long-term trends are fundamental to freight trip generation patterns – for instance, freight transportation was made drastically more efficient and affordable with the near ubiquitous adoption of containerization (Hesse and Rodrigue, 2004), thereby altering global freight flows. In recent decades, some categories of freight transport has become much more *atomized*; that is, broken into smaller discrete loads, shipped in individual time episodes, exploiting comparatively low logistical costs (Ewedairo et al., 2015). Internet transactions have spurred on atomization, as online retailers increasingly compete on delivery times (Wang and Zhou, 2015; Cherrett et al., 2017).

The geography of freight movements is inextricably linked to business strategies. Firms may outsource some or all distribution to a logistical service (Hesse, 2004; Wagner, 2010), resulting in spatially diffused activity patterns, or activities may be concentrated all at one site, reducing or eliminating transportation needed within the firm's own production processes.

Considerable competition has been enabled by more competitive labor relations practices, such as subcontracting (Hesse and Rodrigue, 2004), subcontractor exploitation, and, more recently, piece-rate labor platforms, which may further shift costs and risks on to "employees" (Minter, 2017). Emerging peer-to-peer delivery platforms, such *Airtasker* and *UberEats*, are likely to further permeate into increasingly flexible atomized freight movement markets. The "on-demand" economy, matching consumers with more flexible suppliers in online market platforms, may further disaggregate the origins, transfer points and destinations of urban freight.

New firms and emerging industries also exhibit unique freight carriage characteristics - smaller businesses produce proportionately more freight trips, because they require a similar number of different inputs, in smaller quantities, resulting in more frequent deliveries (Holguín-Veras et al., 2012; Tavasszy, 2006). Additionally, for example, firms may decide to trade directly with consumers, enabling private vehicles to serve as the final distributor of merchandise, or firms may only deliver goods in specific vehicles (Cairns, 2005.) Increasing rates of E-commerce have shifted some retail distribution geographies away from traditional city centers and shopping precincts, while planning policy documents may remain largely silent on attempting to achieve policy objectives through the careful management of emerging platforms of trade (Pettersson et al., 2018). To highlight the diverse nature of firm and freight trip types, Fig. 2 illustrates the full scope of potential internal (within the same site) and external (between sites) freight transportation flows across any production process.

We posit that continued emphasis on refinement of existing freight models within the literature fails to draw in these highly relevant issues of complexity, and highlights the need for improved practice by both modelers, and the decision-makers they attempt to serve. While models may be capable of forecasting the use of new infrastructure supply, they are largely unable to predict the results of demand management strategies or changes of behavior among users (Hatzopoulou and Miller, 2009). Such findings echo Holguín-Veras et al. (2013), who state "the reality is that the explanatory power of most [Freight Trip Generation] models is very low." Nonetheless, there remains a role for modeling in providing indicative figures for consideration, when the surrounding analytical context is adequately informed of these complexities prior to advancing planning or transport policy decisions.

3. Planning by Anecdote? The problem of relying primarily on models

The use of models in planning decision making should be treated with caution, and balanced against other methods of understanding (Lee, 1973). The ontological schism between the rational use of predictive quantitative transport prediction models, and the politically dynamic, deliberative, and participatory processes of planning, lies at the heart of achieving outcomes which reflect land use transport integration aims (te Brömmelstroet and Bertolini, 2008). The simplicity of model outputs may mask the complexity of policy problems that they attempt to detail (Rasouli and Timmermans, 2011). This can engender an illusory perception of their usefulness among their target audience. Employing a single model is often utilized in environments where project options are heavily biased, typically to favor the construction of the project to the benefit of the proponent (Grieco, 1994; Næss, 2011). Resource limitations or conservative organizational attitudes incentivize the continued use of outdated models (Hatzopoulou and Miller, 2009), prolonging the use of old assumptions about urban phenomena. Modelers may utilize the apparent complexity of their methods to manipulate project decisions (Flyvbjerg, 2007), owing to potential conflicts of interest in the development and application of models. The degree to which sponsors work with modelers or a model has been identified as being directly related to the level of trust in the model output (te Brömmelstroet et al., 2017).

Historically, transport planners have claimed an objectivity to their use of such models, sometimes failing to entertain any analysis of underlying assumptions of their practice (Kenworthy, 2012). Use of aggregated quantitative models may facilitate erroneous conclusions and poor decision-making, perpetuating path dependence, and impeding the realization of progressive, adaptive practice (Curtis and Low, 2012). As the resulting land use and infrastructure patterns influenced by models may catalyze the formation of new demand, such models themselves may constitute self-fulfilling prophecies (Robert, 1948; Kenworthy, 2012), by leading to planning decisions which cater for demand which materializes as a result of the investment.

Given the above it is pertinent to consider whether such models may distract from other planning principles or methods. These models may be considered politically convenient, particularly against participatory processes which may be perceived as time consuming, risky, and frustrating (Grieco, 1994). The Planning Support Systems (PSS) literature extensively explores the use of models to assist in deliberation and decision-making, noting several critical elements to success (Pelzer and Geertman, 2014; te Brömmelstroet, 2013). In any event, there are clearly risks associated with the utilization of models, which could be significantly managed by the application of both a range of different models (paying attention to their underlying objectives and assumptions) and the use of an interpretive conceptual framework. Since qualitative and mixed-methods case study approaches can yield valuable insights about freight trip generation (Allen at. al. 2012b, Holguín-Veras et al., 2017), it follows that attempting to plan for freight should incorporate multiple tools and methods beyond quantitative forecasting.

4. Porter's Diamond Model – an application for freight transportation

The challenges associated with the design, refinement, and

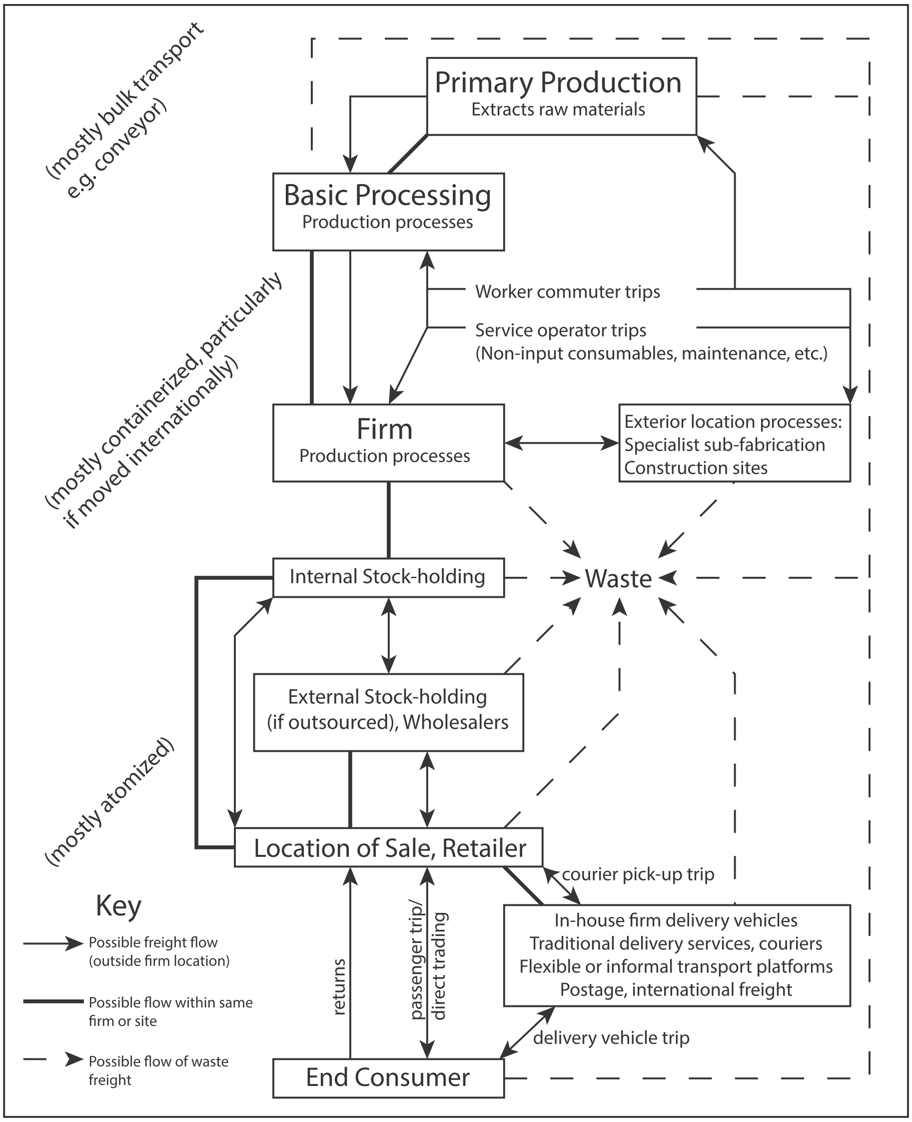

Fig. 2. Possible freight flows and supply chain configurations across production and consumption cycles. Source: Authors.

application of freight models presents an opportunity to improve decision-making practice through the use of a broader conceptual framework. Such a framework may promote the consideration of a broader set of factors and evidence which better represents the complex systems which influence actual transport demand. Since aggregate transport demand is at least partially related to economic activity, we propose the use of an economic competitive advantage framework to explain firm-level characteristics, urban change phenomena, inter-relationships, and consequent transport and land use outcomes. In this way, a more integrated set of factors could be considered than through the use of quantitative transport model outputs in isolation.

4.1. Porter's Diamond Model of Competitive Advantage

Porter's Diamond Model of Competitive Advantage is well established in the economics and planning literature as a conceptual framework for understanding the functions and individual advantages of economies (Porter 1998; Smit, 2010). The Diamond Model framework (Fig. 3) was initially developed to elucidate national competitiveness, and has later been applied to regional and inter-city scales (Smit, 2010).

Cities compete in a global market, specializing in industries owing to local geography, societal factors, economic conditions, and demand attributes (Smit, 2010). To illustrate the utility of the model, we apply principles and phenomena identified within freight generation literature against the Diamond Model. Taking the four components of the model, we summarize their basic definition and relate them to example freight concepts, before presenting a large sample of phenomena evident in the literature within the structure of the Diamond Model.

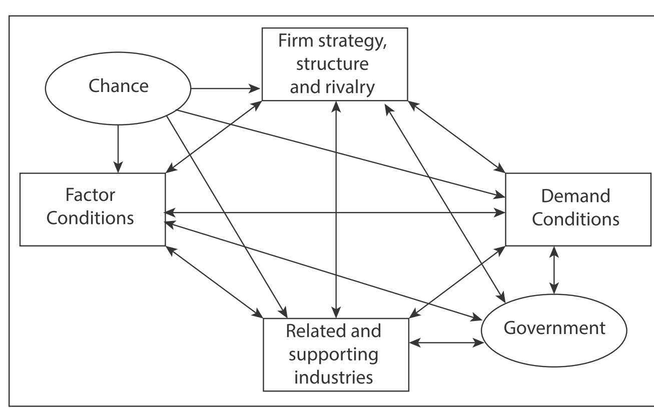

Fig. 3. Porter's Diamond Model of Competitiveness, illustrating paths of interaction between elements. Source: Authors, adapted from (Porter, 1990).

4.1.1. Factor conditions

Factor conditions are simply the inputs for economic production, such as labor, land and natural resources, capital, and infrastructure (Porter, 1990). Factor conditions may be basic (raw materials, unskilled labor), or advanced (improved resources, highly educated labor); basic factors are those which occur naturally, while advanced factors are those which result from innovative human endeavors (Smit, 2010). Further, Porter (1990) divides factors into those which are generalised (of use to many industries, such as highways and capital) and specialized factors, which may only be useful to one industry. Factor conditions determine the economic activity possible within and near cities (Porter, 1998).

4.1.2. Demand conditions

Demand conditions are multi-dimensional, and the *quality* of demand within an economy may be a more highly influential force for competition and innovation than mere overall quantity (Porter, 1996). Demand is highly heterogeneous, and may respond depending on freight transportation options. Economic conditions and fiscal shocks can provoke structural shifts in logistics patterns, which modelers must consider when attempting to formulate forward predictions (Lindsey et al., 2014).

4.1.3. Related and supporting industries

The mix of businesses operating in an economy influences the capacity of that economy to perform, particularly for new, innovative or complex production (Porter, 1990). Transport and logistics firms are the archetypal supporting industry for almost any economic activity which depends on the movement of goods or people.

4.1.4. Firm strategy, structure, and rivalry

Individual firms make decisions depending on economic factors, which then determines their competitiveness within a market (Porter, 1996). For example, atomization of freight is commonly an attribute of “just-in-time” production strategies, or competition based on minimal transit times for distal end-consumer orders. Specialized industry clusters are ubiquitous in developed economies (Mora and Moreno, 2013; Holl, 2004a, 2006), and arise due to the local combination of the determinants of the Diamond Model (Porter, 1996). In terms of travel demand modeling, the strategy of firms and their commercial context is perhaps analogous to the social and cultural factors which have increasingly been recognized as important frontiers to be incorporated into passenger travel prediction models (Rasouli and Timmermans, 2011).

4.1.5. Chance and government

Incidental and seemingly random chance factors can influence competitiveness, often by dramatically changing circumstances in one of the elements of the Diamond Model (Porter, 1996). Porter (1996) further contends that government is an influential factor in relation to the four determinants of competitiveness. “Government” typically encapsulates both macro-level economic policy, and more detailed urban planning regulations, land use governance, public services, and various forms of infrastructure provision. Regulation is a highly influential factor in freight movements (Dablanc, 2007; Muñuzuri et al., 2012; Swamy and Baindur, 2014; Visser and Hassall, 2010), though the outcomes of freight regulations are often not realized as anticipated, again highlighting the complex nature of policy and firm decisions.

4.2. Relationship to freight transportation literature

To illustrate the utility of the Diamond Model as a conceptual framework for understanding freight generation, we characterize salient freight transportation research findings against the model elements (Table 1). These findings are presented primarily to illustrate the utility of the Diamond Model as a structure to interpret knowledge relevant to the production and movement of goods by economies. Key themes identified in the literature are grouped within the “Freight Transportation Concepts” column of Table 1, which outlines the elements of the Freight Diamond Model conceptual framework.

5. Application, discussion and conclusion

This paper has identified the methodological problems associated with traditional freight generation models; identified the possible pitfalls associated with using such models for policy formation; and proposed a novel conceptual framework for improving the consideration of freight for policy development. In doing so, we have synthesized a set of recent findings which highlight the complex spatio-temporal dynamics of freight generation and transport. Key findings have been mapped against Porter's (1990) Diamond Model of Competitive Advantage, revealing that previously disparate urban freight transport planning phenomena could be viewed in a cohesive interrelated theoretical structure. Further analysis may illustrate clearly identifiable relationships between these concepts, which could be charted along the interaction pathways between the elements of the Diamond, shown in Fig. 3. In terms of application for practice, we posit that the utilization of this novel freight conceptualization model could be twofold as outlined below.

Firstly, the Freight Diamond Model may act as a conceptual benchmark or interpretive framework for conventional freight modeling activities, bringing limitations and relevant considerations to the fore, illustrating the other complex dynamics at play, and helping to provide potential explanations for unique local findings. te Brömmelstroet et al. (2017) find, through surveying planning practitioners, that governance structures in which a model is applied and interpreted influenced the propriety of the use of the model. In this sense, the Diamond Model may reduce the interpretation and policy application problems detailed in Section 3 of this paper. This conceptual framework may also improve practice by providing policymakers with a diverse range of potential and alternative options and target factors for improving overall transport sustainability, by detailing more of the opportunities for innovative and reflexive policy against a much broader scope of considerations.

Secondly, the Freight Diamond Model may form the basis for a complex firm, local, regional or national freight generation model, which attempts to incorporate the full gamut of possible contextual, social, environmental, economic, and governmental factors which influence freight trip generation. Such a model would involve a myriad of potential variables identified in Sections 2 and 4 of this manuscript. Results of local studies could be interpreted relative to such variables, enabling freight generation researchers to interrogate contextual factors, and generate algorithms accordingly. A generalised evidence reporting structure incorporating the above elements could be devised, which may partially address the land use definition problem noted in Section 2.2. Government regulations and policies might also be evaluated with reference to the Freight Diamond Model, generating broader discursive discussion between policy-makers. Further, given the element of chance incorporated into Porter's Diamond Model, and in the activity of cities, a quantitative model which enabled Monto Carlo simulations could provoke rigorous policy discussion through the exploration of alternative scenarios. For instance, the influences of potentially uncontrollable economic, policy or spatial variables contained within the points of the Diamond Model could be appraised by running several random chance tests, assisting decision-makers in understanding the inherent uncertainty involved in planning for transport patterns.

Further case study research is needed to test and refine such a model, and critically evaluate whether it is versatile enough to overcome current interpretive and contextual phenomena. Key considerations, such as the impacts and consequences of congestion, need to be clearly differentiated for land use categories (Sweet, 2014). Diversity

Table 1
The Diamond Model as a conceptual framework – Application to Freight factors.

Porter's Diamond Model Element	Components adapted from (Smit, 2010)	Freight Transportation Concepts	Example Findings & Supporting Literature
Factor Conditions	Human resources	Available labor	● Low per-capita incomes decrease transport labor costs and possibly land costs (Lindsey et al., 2014). ● Labor factors influence supply chain design, through export competitiveness, outsourcing etc. ● Transport contributes a sizable proportion of all employment (Cui et al., 2015) ● Labor relations and market platforms may influence the total labor market for freight distribution (Minter, 2017)
	Physical resources	Landforms and features	● Port locations – expensive inner urban land results in formation of inland freight hubs, intermodal facilities (Cidell, 2010) ● Natural geography influences international competitiveness and location of freight corridors (Hesse and Rodrigue, 2004; Roso et al., 2009) ● Terrain limits infrastructure design options and consequently location of logistics firms (Günay et al., 2016) ● Land cost is an important consideration for logistics uses (Verhetsel et al., 2015; Hesse, 2004; Hesse and Rodrigue, 2004), resulting broadly in relocations to low cost peri-urban land ● Availability of suitable lots for logistical and industrial uses influences distribution (Jakubicek and Woudsma, 2011)
		Natural basic resources	● Natural resources influence bulk materials transport demand, competitiveness between sectors ● Cost of energy/transport fuel (Porter, 1998)
	Knowledge resources	Supply chain design	● Desirability of urban locations is important for freight generating firms requiring skilled workers (Jakubicek and Woudsma, 2011)
	Capital resources and infrastructure	Available technology	● Containerization (Hesse and Rodrigue, 2004) ● Fleet and package tracking and optimization technology ● New technologies (3D printers, etc.) changing industrial production locations; use of drones, robotics, and autonomous vehicles for warehousing and freight delivery (Mckinnon, 2016)
		Locations of intra and inter-national freight corridors	● High-capacity corridors of freight between major cities influence, and are influenced by, local transport networks within cities, implications for regional planning (Clott and Hartman, 2016)
		Site factors Building attributes	● Activities enabled by facilities; e.g. receiving and dispatching technologies, automatic freight receiving portals at destinations opening up receiving hours (Aljohani and Thompson, 2016)
Demand Conditions	Global demand	Broad economic conditions, shocks	● Macro-level demand, global trade balances influence freight movements (Lindsey et al., 2014)
	Scale or market, sophistication of market preferences	Consumption habits Mass vs Bespoke production	● Increasingly product-type specific supply chains (Tavasszy et al., 2012) ● Customer choices to collect purchases rather than purchase delivery; delivery services may replace and substantially reduce supermarket shopping trip travel (Cairns, 2005) ● The sharing economy disruptions to traditional production and consumption patterns
	Geographic distribution of consumer demand	Online Retail Just-in-time production	● Industrial property demand factors (Lindsey et al., 2014) ● Changing delivery locations (Cherrett et al., 2017), increasingly deliveries directly to residences (Wang and Zhou, 2015) ● Changing urban land use structures changes movement patterns, (Allen et al., 2012a), as do local delivery timing requirements ● Logistics firms desire proximity to customers (Jakubicek and Woudsma, 2011), use of roving freight distribution depots (Arvidsson and Pazirandeh, 2017) ● Density of businesses contributes to freight congestion (Joubert and Axhausen, 2011)

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Table 1 (*continued*)

Porter's Diamond Model Element	Components adapted from (Smit, 2010)	Freight Transportation Concepts	Example Findings & Supporting Literature
Firm strategy, structure and rivalry	Rivalry and competitive options in markets	Locational choice, logistic chain choices	● Profitability of product, consumer demand profile, delivery model influences firms strategic transport decisions (Holl, 2006) ● Logistics facilities strongly desire the capacity and regulatory freedom to operate 24/7 (Jakubicek and Woudsma, 2011) ● Firms with poorer access to freight networks are observed to be more specialized, owing to a need to differentiate to offset increased transport costs (Mora and Moreno, 2013)
		Consumer access choice options	● Differences in demand between sites depending on highly local transport infrastructure (Greene and Kannan, 2011), and between different urban/suburban contexts (Clifton et al., 2015)
		Partnerships	● Flexible transport services (Uber, Shyp) partnering with origin businesses to offer rapid, individualized delivery services (Aljohani and Thompson, 2016) ● Consolidation of many deliveries bound for the same building or area may significantly reduce overall freight trips and improve sustainability of freight operations (Cherrett et al., 2012; Olsson and Woxenius, 2014)
	International competitiveness	Port/hub selection	● Poorly performing national economies discourage industrial space consumption (Lindsey et al., 2014)
	Firm size and industry	Delivery or service type and consequent vehicle choice	● No simple relationship between freight mass generation and freight trip generation (Holguín-Veras et al., 2011) ● Significance of service (not 'freight') delivery vehicles as class of non-passenger transport (Ellison et al., 2017) ● Structure of freight industry firms: proliferation of subcontractors, casualization of transportation labor (Minter, 2017) ● Micro Urban Consolidation Centers (MUCC) – modal transfer points for inner-urban deliveries (Aljohani and Thompson, 2016) ● Supermarkets may in-source logistics to capitalise on opportunity to use trucks as branding, and to utilize retail floorspace as local warehousing (Kumar 2008)
Related and supporting industries	Specialization and clustering	Industrial park and facilities	● Industrial land investment and development (often outside formal planning controls) (Lindsey et al., 2014) ● Refueling, transport industry support services ● Practices of stevedores and maritime unions
	Economies of Scale	Freight hubs, warehousing	● Centralization of stockholding for economies of scale (Allen et al., 2012a) ● Outsourcing of logistics activities within firms (Cui et al., 2015)
	Synergy Symbiosis	Clusters	● Transfer of innovation and sharing of large assets between neighboring firms (Ellison et al., 2010)

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Table 1 (*continued*)

Porter's Diamond Model Element	Components adapted from (Smit, 2010)	Freight Transportation Concepts	Example Findings & Supporting Literature
Government [Influencing Factor]	Geopolitical economic Strategy	Incentives, Tariffs and economic instruments Legal Systems	● Openness of trade (Tavasszy et al., 2012) ● Pricing of transport externalities (Glaeser and Kohlhase, 2003) ● Legal, cultural, technical factors influence actual freight manifestation (Cui et al., 2015, 590) ● Influence of regulatory settings on market formation (Minter, 2017)
	Urban/Metropolitan Planning	Infrastructure investment, Logistics Hub planning	● "Soft" infrastructure investments to attract globally mobile firms (Lindsey et al., 2014) ● Airport planning and hub generation, diversification of airport land use and governance (Freestone and Baker, 2011). Airport hubs may depend on lighter vehicles (Giuliano et al., 2017); significant in long-distance rapid online retail ● Local amenity-oriented planning discouraging established heavy freight land uses from inner-urban zones (Aljohani and Thompson, 2016)
		Road Supply and regulation	● Road pricing, restrictions, weight and mass limits etc. (Swamy and Baindur, 2014) ● Parking and loading regulations (Giuliano et al., 2017)
		Intermodality, Multimodality	● Regional access to multi-modal facilities (Jakubicek and Woudsma, 2011) ● Increased road supply may induce new demand (Cervero, 2002) ● Competitiveness of railways (Haywood, 1999) ● Use of public transport services a means of moving small payloads deliveries, especially in congested cities (Baindur and Macário, 2013) ● New models of roving freight hubs with bicycles, electric vehicles, for urban "last mile" (Arvidsson and Pazirandeh, 2017)
		Safety	● Road safety policy objectives (Woudsma, 2001)
	Local transport regulations	Traffic and demand management, parking regulations	● NIMBY attitudes to logistical activity land uses (Jakubicek and Woudsma, 2011) ● Highly charged local planning issues impeding regional objectives (Pellegram, 2001) ● Depressed residential land values proximate to freight infrastructure (Giuliano et al., 2017)
		Land regulation and use preservation	● Government policy may assist in ensuring inner-city logistics facilities are protected from displacement (with the ultimate of objective of reducing total distance of all journeys) (Aljohani and Thompson, 2016)

between or within land use categories may not become fully event without testing; for instance, key elements of the model relevant to globalized commodity supply chains may hold little relevance to the effort of understanding the delivery traffic generated by highly specialized local agriculture. The relationship between different factors within the conceptual framework – such as the effect of labor market conditions on firm delivery behavior – could be clarified for specific land use types through interviews with key stakeholders.

Ultimately, the application of this framework, particularly as relevant research continues to emerge, should assist policy-makers in ensuring that critical factors and dependencies are not ignored, by highlighting all the concepts that need to be considered. In addition to providing a thought structure through which to consider the potential implications of land use and transport policy adjustments, the use of this framework may also better accentuate the limits of existing quantitative forecasting. The application of a theoretical framework may counter the "black-box" opacity of quantitative models, placing analytical skills (and, by extension, interpretive power) back in the hands of the policy-makers who must attempt to balance a broad spectrum of real-world outcomes. The use of freight generation theory may also demand the employment of a more diverse set of planning expertise at the policy-making table, and throw renewed emphasis on qualitative and mixed-methods freight research. Recognizing the complexities of these dynamics will enable urban planners to acknowledge and incorporate the degrees of uncertainty and the inherent constant change in cities when attempting to devise and refine freight transport policy.

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References

Aljohani, K., Thompson, R.G., 2016. Impacts of logistics sprawl on the urban environment and logistics: taxonomy and review of literature. J. Transport Geogr. 57, 255–263.
Allen, J., Browne, M., Cherrett, T., 2012a. Investigating relationships between road freight transport, facility location, logistics management and urban form. J. Transport Geogr. 24, 45–57.
Allen, J., Browne, M., Cherrett, T., 2012b. Survey techniques in urban freight transport studies. Transport Rev. 32, 287–311.
Arvidsson, N., Pazirandeh, A., 2017. An ex ante evaluation of mobile depots in cities: a sustainability perspective. Inter. J. Sustain. Transport. 11 (8), 623–632.
Baindur, D., Macário, R.M., 2013. Mumbai lunch box delivery system: a transferable benchmark in urban logistics? Res. Transport. Econ. 38, 110–121.
Ballantyne, E.E.F., Lindholm, M., Whiteing, A.W., 2013. A comparative study of urban freight transport planning: addressing stakeholder needs. J. Transport Geogr. 32, 93–101.
Cairns, S., 2005. Delivering supermarket shopping: more or less traffic? Transport Rev. 25, 51–84.
Cervero, R., 2002. Induced travel demand: research design, empirical evidence, and normative policies. J. Plann. Lit. 17, 3–20.
Chenery, H., Clark, P., 1959. Interindustry Economics. Wiley, N.Y N.Y.
Cherrett, T., Allen, J., Mcleod, F., Maynard, S., Hickford, A., Browne, M., 2012. Understanding urban freight activity – key issues for freight planning. J. Transport Geogr. 24, 22–32.
Cherrett, T., Dickinson, J., Mcleod, F., SIT, J., Bailey, G., Whittle, G., 2017. Logistics impacts of student online shopping – evaluating delivery consolidation to halls of residence. Transport. Res. C Emerg. Technol. 78, 111–128.
Chhetri, P., Butcher, T., Corbitt, B., 2014. Characterising spatial logistics employment clusters. Int. J. Phys. Distrib. Logist. Manag. 44, 221–241.
Cidell, J., 2010. Concentration and decentralization: the new geography of freight distribution in US metropolitan areas. J. Transport Geogr. 18, 363–371.
Clifton, K.J., Currans, Kristina M., Muhs, C.D., 2015. Adjusting ITE's trip generation handbook for urban context. J. Transp. Land Use 8.
Clott, C., Hartman, B.C., 2016. Supply chain integration, landside operations and port accessibility in metropolitan Chicago. J. Transport Geogr. 51, 130–139.
Cui, J., Dodson, J., Hall, P.V., 2015. Planning for urban freight transport: an overview. Transport Rev. 35, 583–598.
Curtis, C., Low, N., 2012. Institutional Barriers to Sustainable Transport. Ashgate.
D'este, G., 2007. Urban freight movement modeling. In: Hensher, D.A., Button, K.J. (Eds.), Handbook of Transport Modelling, second ed. .
Dablanc, L., 2007. Goods transport in large European cities: difficult to organize, difficult to modernize. Transport. Res. Pol. Pract. 41, 280–285.
Dablanc, L., Giuliano, G., Holliday, K., O'brien, T., 2013. Best practices in urban freight management. Transport. Res. Rec.: J. Transport. Res. Board 2379, 29–38.
Ellison, G., Glaeser, E.L., Kerr, W.R., 2010. What causes industry agglomeration? Evidence from coagglomeration patterns. Am. Econ. Rev. 100, 1195–1213.
Ellison, R.B., Teye, C., Hensher, D.A., 2017. Modelling Sydney's light commercial service vehicles. Transport. Res. Pol. Pract. 96, 79–89.
Ewedairo, K., Chhetri, P., Dodson, J., 2015. A GIS methodology for estimating the transport network impedance to last-mile delivery. In: State of Australian Cities National Conference. Gold Coast, Queensland, Australia.
Flyvbjerg, B., 2007. Megaproject Policy and Planning: Problems, Causes, Cures. Department of Development and Planning, Aalborg University.
Freedman, D.A., 1999. Ecological Inference and the Ecological Fallacy. Department of Statistics, UC Berkeley Technical Report No. 549. California. http://statistics.berkeley.edu/sites/default/files/tech-reports/549.ps.Z.
Freestone, R., Baker, D., 2011. Spatial planning models of airport-driven urban development. J. Plann. Lit. 26, 263–279.
Giuliano, G., Kang, S., Yuan, Q., 2017. Using Proxies to Describe the Metropolitan Freight Landscape. Urban Studies, 0042098017691438.
Glaeser, E.L., Kohlhase, J.E., 2003. Cities, regions and the decline of transport costs. Pap. Reg. Sci. 83, 197–228.
Greene, C.P.E.P., Kannan, V.P.E., 2011. A trip generation study of coffee/donut shops in western New York. Inst. Transport. Eng.. ITE J. 81, 40–45.
Grieco, M., 1994. The Impact of Transport Investment Projects upon the Inner City: a Literature Review. Avebury Publishing Company, Aldershot, England.
Gulyani, S., 2001. Effects of poor transportation on lean production and industrial clustering: evidence from the indian auto industry. World Dev. 29, 1157–1177.
Günay, G., Ergün, G., Gökaşar, I., 2016. Conditional freight trip generation modelling. J. Transport Geogr. 54, 102–111.
Guttenberg, A.Z., 1993. The Language of Planning : Essays on the Origins and Ends of American Planning Thought. University of Illinois Press, Urbana, Illinois.
Hatzopoulou, M., Miller, E.J., 2009. Transport policy evaluation in metropolitan areas: the role of modelling in decision-making. Transport. Res. Part A 43, 323–338.
Haywood, R., 1999. Land development implications of the British rail freight renaissance. J. Transport Geogr. 7, 263–275.
Hesse, M., 2004. Land for logistics: locational dynamics, real estate markets and political regulation of regional distribution complexes. Tijdschr. Econ. Soc. Geogr. 95, 162–173.
Hesse, M., Rodrigue, J.-P., 2004. The transport geography of logistics and freight distribution. J. Transport Geogr. 12, 171–184.
Holguín-Veras, J., Amaya Leal, J., Seruya, B.B., 2017. Urban freight policymaking: the role of qualitative and quantitative research. Transport Pol. 56, 75–85.
Holguín-Veras, J., Jaller, M., Destro, L., Ban, X.J., Lawson, C., Levinson, H.S., 2011. Freight generation, freight trip generation, and perils of using constant trip rates. Transport. Res. Rec. 68–81.
Holguín-Veras, J., Jaller, M., Sanchez-Diaz, I., Wojtowicz, J., Campbell, S., Levinson, H., Lawson, C., Powers, E.L., Tavasszy, L., 2012. NCFRP Report 19: Freight Trip Generation and Land Use. Transportation Research Board, Washington, DC.
Holguín-Veras, J., Sánchez-Díaz, I., Lawson, C., Jaller, M., Campbell, S., Levinson, H., Shin, H.-S., 2013. Transferability of freight trip generation models. Transport. Res. Rec.: J. Transport. Res. Board 2379, 1–8.
Holl, A., 2004a. Manufacturing location and impacts of road transport infrastructure: empirical evidence from Spain. Reg. Sci. Urban Econ. 34, 341–363.
Holl, A., 2004b. Start-ups and relocations: manufacturing plant location in Portugal. Pap. Reg. Sci. 83, 649–668.
Holl, A., 2006. A review of the firm-level role of transport infrastructure with implications for transport project evaluation. J. Plann. Lit. 21, 3–14.
Hymel, K.M., Small, K.A., Van Dender, K., 2010. Induced demand and rebound effects in road transport. Transp. Res. Part B Methodol. 44, 1220–1241.
Iding, M.H.E., Meester, W.J., Tavasszy, L., 2002. Freight trip generation by firms. 42nd congress of the European Regional Science Association. In: From Industry to Advanced Services - Perspectives of European Metropolitan Regions, (Dortmund, Germany).
Institute Of Transportation Engineers, 2012. Trip Generation Manual. Institute of Transportation Engineers, Washington, D.C.
Jakubicek, P., Woudsma, C., 2011. Proximity, land, labor and planning? Logistics industry perspectives on facility location. Transport Rev. 3, 161–173.
Jaller, M., Wang, X., Holguín-Veras, J., 2015. Large urban freight traffic generators: opportunities for city logistics initiatives. J. Transp. Land Use 8, 51–67.
Jonsson, D., Berglund, S., Almstrom, P., Algers, S., 2011. The usefulness of transport models in Swedish planning practice. Transport Rev. 31 (2), 251–265.
Joubert, J.W., Axhausen, K.W., 2011. Inferring commercial vehicle activities in Gauteng, South Africa. J. Transport Geogr. 19, 115–124.
Kenworthy, J., 2012. Don't shoot me, I'm only the transport planner (apologies to Sir Elton John). World Transport Pol. Pract. 18, 6–26.
Kumar, I., Zhalnin, A., Kim, A., Beaulieu, L.J., 2017. Transportation and logistics cluster competitive advantages in the U.S. regions: a cross-sectional and spatio-temporal analysis. Res. Transport. Econ. 61, 25–36.
Kumar, S., 2008. A study of the supermarket industry and its growing logistics capabilities. Int. J. Retail Distrib. Manag. 36, 192–211.
Lee, D.B., 1973. Requiem for large-scale models. J. Am. Inst. Plan. 39 (3), 163–178.
Lindsey, C., Mahmassani, H.S., Mullarkey, M., Nash, T., Rothberg, S., 2014. Industrial space demand and freight transportation activity: exploring the connection. J. Transport Geogr. 37, 93–101.

Marsden, G., Ballantyne, E.E.F., Whiteing, A.E., 2011. An analysis of local authority views on treatment of urban freigth in the UK. In: 43rd Universities' Transport Study Group Conference, vols. 5–7 (January, Milton Keynes).
Martínez, F., 2003. Location externalities: effects on modeling, infrastructure provision and optimal planning. In: Hensher, D.A., Button, K.J. (Eds.), Handbook of Transport and the Environment.
Mckinnon, A.C., 2016. The possible impact of 3D printing and drones on last-mile logistics: an exploratory study. Built. Environ. 42, 617–629.
Minter, K., 2017. Negotiating labour standards in the gig economy: airtasker and unions new south wales. Econ. Lab. Relat. Rev. 28, 438–454.
Mora, T., Moreno, R., 2013. The role of network access on regional specialization in manufacturing across Europe. Reg. Stud. 47, 950–962.
Mullen, C., Marsden, G., 2015. Transport, economic competitiveness and competition: a city perspective. J. Transport Geogr. 49, 1–8.
Muñuzuri, J., Cortés, P., Guadix, J., Onieva, L., 2012. City logistics in Spain: why it might never work. Cities 29, 133–141.
Muñuzuri, J., Cortés, P., Onieva, L., Guadix, J., 2010. Modelling peak-hour urban freight movements with limited data availability. Comput. Ind. Eng. 59, 34–44.
Næss, P., 2011. The third limfjord crossing: a case of pessimism bias and knowledge filtering. Transport Rev. 31, 231–249.
Ollson, J., Woxenius, J., 2014. Localisation of freight consolidation centres serving small road hauliers in a wider urban area: barriers for more efficient freight deliveries in Gothenburg. J. Transport Geogr. 34, 25–33.
Ortuzar, J.D.D., Willumsen, L.G., 2011. Modelling Transport. Wiley-Blackwell, Oxford, Oxford.
Pas, E., 1990. Is travel demand analysis and modeling in the doldrums? In: JONES, P. (Ed.), Developments in Dynamic and Activity-based Approaches to Travel Analysis. Gower Publishing Company Limited, Aldershot, England.
Pellegram, A., 2001. Strategic land use planning for freight: the experience of the Port of London Authority, 1994–1999. Transport Pol. 8, 11–18.
Pelzer, P., Geertman, S., 2014. Planning support systems and interdisciplinary learning. Plann. Theor. Pract. 15, 527–542.
Pettersson, F., Hiselius-Winslott, L., Koglin, T., 2018. E-commerce and Urban Planning – Comparing Knowledge Claims in Research and Planning Practice, Urban. Plan. Transport. Res. 6, 1–21.
Porter, M.E., 1990. The Competitive Advantage of Nations. Macmillan, London.
Porter, M.E., 1996. Competitive advantage, agglomeration economies, and regional policy. Int. Reg. Sci. Rev. 19, 85–90.
Porter, M.E., 1998. Clusters and the new economics of competition. Harv. Bus. Rev. 76, 77–90.
Ralph, K., Delbosc, A., 2017. I'm multimodal, aren't you? How ego-centric anchoring biases experts' perceptions of travel patterns. Transport. Res. Pol. Pract. 100, 283–293.
Rasouli, S., Timmermans, H., 2011. Transport models and urban planning practice: experiences with albatross. Transport Rev. 31, 199–207.
Robert, K.M., 1948. The self-fulfilling prophecy. Antioch Rev. 8, 193–210.
Rodrigue, J.P., Hesse, M., 2007. Globalized trade and logistics: north American perspectives. In: Leinbach, T.R., Capineri, C. (Eds.), Globalized Freight Transport : Intermodality, E-Commerce, Logistics and Sustainability. Edward Elgar Publishing Limited, Cheltenham.
Roso, V., Woxenius, J., Lumsden, K., 2009. The dry port concept: connecting container seaports with the hinterland. J. Transport Geogr. 17, 338–345.
Sánchez-Díaz, I., 2016. Modeling urban freight generation: a study of commercial establishments' freight needs. Transport. Res. Pol. Pract. 102, 3–17.
Smit, A.J., 2010. The Competitive Advantage of Nations : Is Porter's Diamond Framework a New Theory that Explains the International Competitiveness of Countries? pp. 105–130 14.
Swamy, S., Baindur, D., 2014. Managing urban freight transport in an expanding city — case study of Ahmedabad. Res. Transport. Bus. Manag. 11, 5–14.
Sweet, M.N., 2014. Do firms flee traffic congestion? J. Transport Geogr. 35, 40–49.
Tavasszy, L., 2006. Freight modeling: an overview of international experiences. In: Hancock, K.L. (Ed.), Freight Demand Modeling - Tools for Public-sector Decision Making. Transportation Research Board.
Tavasszy, L.A., Ruijgrok, K., Davydenko, I., 2012. Incorporating logistics in freight transport demand models: state-of-the-art and research opportunities. Transport Rev. 32, 203–219.
Taylor, N., 1998. Urban Planning Theory since 1945. SAGE Publishing, New York.
Taylor, S.Y., Button, K.J., 1999. Modelling Urban Freight : what Works, what Doesn't Work? Clayton. Institute of Transport Studies, Victoria.
TE Brömmelstroet, M.T., 2013. Performance of Planning Support Systems: what is it, and how do we report on it? Comput. Environ. Urban Syst. 41, 299–308.
TE Brömmelstroet, M., Bertolini, L., 2008. Developing land use and transport PSS: meaningful information through a dialogue between modelers and planners. Transport Pol. 15, 251–259.
TE Brömmelstroet, M., Skou Nicolaisen, M., Büttner, B., Ferreira, A., 2017. Experiences with transportation models: an international survey of planning practices. Transport Pol. 58, 10–18.
Timmermans, H., Arentze, T.A., 2014. Activity-based models of travel demand: promises, progress and prospects. Int. J. Unity Sci. 18, 31–60.
Verhetsel, A., Kessels, R., Goos, P., Zijlstra, T., Blomme, N., Cant, J., 2015. Location of logistics companies: a stated preference study to disentangle the impact of accessibility. J. Transport Geogr. 42, 110–121.
Visser, J., Hassall, K., 2010. What should be the balance between free markets and a not so 'Invisible Hand' in urban freight regulation and land use: Dutch and Australian experiences. In: Tanguchi, E., Thompson, R.G. (Eds.), 6th International Conference on City Logistics. Elsevier Science Bv, Amsterdam.
Wagner, T., 2010. Regional traffic impacts of logistics-related land use. Transport Pol. 17, 224–229.
Wang, X., Zhou, Y., 2015. Deliveries to residential units: a rising form of freight transportation in the U.S. Transport. Res. C Emerg. Technol. 58 (Part A), 46–55.
Wegener, M., 2004. Overview of land use transport models. In: Hensher, D.A., Button, K.J., Haynes, K.E., Stopher, P.R. (Eds.), Handbook of Transport Geography and Spatial Systems. Elsevier, Amsterdam.
Wegener, M., 2011. From macro to micro—how much micro is too much? Transport Rev. 31, 161–177.
Woudsma, C., 2001. Understanding the movement of goods, not people: issues, evidence and potential. Urban Stud. 38, 2439–2455.
Woudsma, C., Jensen, J.F., Kanaroglou, P., Maoh, H., 2008. Logistics land use and the city: a spatial–temporal modeling approach. Transport. Res. E Logist. Transport. Rev. + 44, 277–297.