Understanding and Planning for Freight Movement in Cities: Practices and Challenges

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Abstract

Planning for freight presents a perpetual challenge for governments. Understanding freight flows has attracted increasing research attention, especially as freight patterns undergo systematic changes, and as urbanisation intensifies many of the impacts associated with the movements of goods. However, this research is often fragmented across fields of inquiry, and can be difficult to translate directly to address difficult problems in planning practice. Many methods of conventional practice pay limited consideration to the significant social and environmental impacts of freight, and governments may have little insight on how to facilitate economic activity without incurring significant negative external costs. To date, there has been limited focus on drawing together these problems and existing knowledge to inform practicing urban planners.

Drawing upon an international literature review, and the practical experience of the authors, this paper critically assesses the nature of the challenge of understanding and planning for freight movement within cities, especially with reference to achieving more sustainable outcomes. In doing so, we elucidate guidance for broader analytical and policy approaches in order to meet public interest objectives, with specific reference to the nature of policy problems, and existing knowledge relating to land use types.

Keywords

Freight, Freight Generation, Logistics, Trip Generation, Planning

1. Introduction

Planning for freight movement is of key interest for cities and regions seeking to enhance economic productivity while reducing the significant negative social, economic, and environmental impacts of the movement of goods. Urban planners often face questions about freight relating to site and building design needs, land requirements, potential interface issues between land uses, and the management of local streets and parking (Stathopoulos, Valeri, & Marcucci, 2012). Beyond local planning, there are also broader long-run planning questions, especially concerning economic development, employment provision and distribution, infrastructure planning, and changing industry structures which are closely tied to freight patterns (McLeod, Schapper, Curtis, & Graham, 2019). Policy-makers are increasingly

recognising the significant regional development implications of freight transportation geography (Closs & Bolumole, 2015), though planners often have a limited set of blunt policy tools with which to operate; typically either instituted through land use zoning and the regulation of public street space. Planners are also tasked with resolving emergent issues resulting from urban freight movements, especially at the interface of land uses and transport flows in existing urban areas.

There is limited available planning knowledge to inform decision-making relating to urban freight. This is most obvious in the paucity of local information about freight generation and the dimensions of existing flows of goods (D'Este, 2007). Planning agencies can lack internal expertise in freight planning and policy development (Ballantyne & Lindholm, 2014; Lindholm & Blinge, 2014). It is also broadly recognised that the movement of freight receives comparatively little research and public policy attention, even though the negative externalities of the total scope of freight movements may be comparable to those of passenger transport (Cui, Dodson, & Hall, 2015; Ogden, 1992).

Collecting rich and meaningful data about freight for a specific context can be difficult and resource-intensive (Allen, Browne, & Cherrett, 2012b; Ambrosini & Routhier, 2004), especially as freight-moving firms often have incentives to withhold data and information to protect their competitive positions (Ambrosini & Routhier, 2004, p. 59; Hensher & Brewer, 2001; Lindawati, van Schagen, Goh, & de Souza, 2014; Stopher, 2007, p. 289; Tavasszy & de Jong, 2014, p. 229). Even where basic data about freight flows is collected, it can lack explanatory depth as to the specific goods being moved and the factors underlying these patterns of movement (Allen, Browne, et al., 2012b; Witlox, 2015). Freight data may also be aggregated at a spatial or temporal scale too course to support local analyses (Tavasszy & de Jong, 2014).

Research about freight is fragmented across a wide span of academic and professional fields (Hall, Hesse, & Rodrigue, 2016), and is sometimes presented with limited exploration of the implications for decision-making in cities. Thus, the focus of much freight transport planning research and practice to date has centred upon the synthesis of a corpus of knowledge framed around land use as the unit against which this evidence is framed and translated. Conventionally, this has taken the form of trip generation rates reported for quite specific land use types (Holguín-Veras et al., 2012; Iding, Meester, & Tavasszy, 2002; Institute of Transportation Engineers, 2012; Lawson et al., 2012). However, the validity of this approach has been questioned, given variance between geographies, and in the path dependence that such predict-and-provide approaches may engender (McLeod et al., 2019; Millard-Ball, 2015). Planning jurisdictions increasingly grapple with freight flows recognised as being unsustainable and in conflict with broader amenity and urban development goals (Anderson, Allen, & Browne, 2005; Behrends, Lindholm, & Woxenius, 2008), which may counter conventional planning practices. Recognising these significant planning challenges, it is pertinent to critically review the structure and application of knowledge of freight within cities.

1.1 Research Purpose and Approach

This paper collates and synthesises existing knowledge about how freight is generated from the perspective of urban planners trying to manage it. The methodological issues associated with attempts to derive meaning from data collected about freight are explored, and a conceptual framework for application to understand freight planning problems is presented. Drawing upon a broad sample of literature, and on the professional practice experience of the authors, this paper aims to provide planners with an overview of current knowledge in freight, while elucidating key challenges and opportunities in for better understanding and facilitating the movement of goods within cities.

A systemic literature review of published material relating to the generation of freight by land uses within cities was undertaken, interrogating a comprehensive set of planning journals and academic databases. Searches aimed to yield papers which concerned both freight and land use. Searches through large databases (Google Scholar, Scopus, Web of Science) were conducted to achieve a broader coverage of all literature. Searches were also conducted for research specific to specific categories of land uses. Only papers in English were sampled. Iterative and opportunistic sampling, snowballing, and collation of sources from other projects was undertaken over approximately three years, to develop an extensive sample of academic and grey literature. In all, we collated 220 sources relating to the research question. While a broad search strategy was adopted, the aim was not to be exhaustive, but to synthesise findings to support planners in navigating the inherent challenges and ambiguities in trying to understand and manage freight within cities.

The findings of this paper are presented in three parts. In section 2, we critically appraise research reporting the issues in planning for urban freight which may necessitate divergent planning practice, and the potential barriers to practice improvement. In section 3, we detail concepts of freight and freight trip generation, and associated planning approaches (as conventionally applied at the level of land uses). In section 4, we collate literature against land uses along product supply chains to synthesise findings applicable to planning issues. Lastly, we reflect upon the need to continue bridging freight research and planning more closely to continuously adapt to and manage new forms and patterns of goods movements within cities.

2. Challenges in Freight Planning Practice

Urban planners seeking to manage urban freight issues must contend with several potential barriers in the development and application of holistic knowledge in applied policy contexts. Many of these barriers may perpetuate path-dependent reversion to methods of practice based upon reference trip rates, or methods based upon values and objectives which consider only a limited set of outcomes (Curtis & Low, 2012). These issues are of critical importance in framing the collation, synthesis, and application of knowledge about freight.

2.1 Contested Problem Definition, Discrete Disciplines, and Distributed Decision-Making

Planning is fundamentally concerned with understanding and managing competing interests to meet broader public interests. Increasingly, the lens of sustainability has been applied to the management of freight and logistics to meet public interests relating to social, economic, and environmental outcomes (Allen, Anderson, Browne, & Jones, 2000; Anderson et al., 2005; Behrends et al., 2008; McKinnon, Browne, Whiteing, & Piecyk, 2015). While sustainability may represent an over-arching framework for policy design, it is fundamentally difficult to operationalise because of competing policy interests, the fragmented objectives of stakeholders, uncertainty on the feasibility and efficacy of policy measures, and the fragmented nature of the full suite of policies which influence freight (Ballantyne, Lindholm, & Whiteing, 2013; Muñuzuri, Cortés, Guadix, & Onieva, 2012). This is often exemplified in reactive policy responses only materialising due to political pressures from stakeholders facing immediate operational problems (Legacy, Curtis, & Scheurer, 2017), rather than through efforts to undertake planning with wider objectives and broader timescales.

Freight issues involve by a wide range of professional fields, who each retain a focus on a specific discipline, and which tend to form and guard rationalist domains of specialisation (Vigar, 2002). Freight is conceptualised and analysed differently between fields in economics, geography, planning, engineering, and transportation (Hall et al., 2016). For freight in particular, governments and managers of infrastructure which may represent monopolies (such as ports, intermodal terminals, and corridors) may act with limited insight into the intertemoporal implications of their decisions on regional freight markets (Hall, 2007; Visser & Hassall, 2010). This can challenge planners seeking to coordinate an integrated approach to addressing urban freight management issues.

2.2 Quiet or Ambiguous Structural Changes

Freight activity within cities is highly diverse. At a basic level, “freight” can encapsulate the movements of raw materials, goods at the intermediate stages of supply chains, deliveries to points of sale or consumers, traffic supporting construction activity, vehicles used to deliver services, and in the removal of waste (Carter, Crum, & Liane Easton, 2011). Many of these flows may not be immediately recognised as being freight movements.

The movements of freight are dynamic, as consumer demands change, and as firms seek to exploit new supply chain design strategies and technologies to enhance their competitiveness (Mentzer, 2004). Firms and consumers are continually shifting the way they move goods, especially as structural changes in the costs of transport (Glaeser & Kohlhase, 2003), the value of land (Hesse, 2004), land use structures (Woudsma, 2016), bases of competition (Porter, 2016) - and as other market factors present opportunities to reshape the supply chains which carry the physical material used by people (Boerkamps, van Binsbergen, & Bovy, 2000). For instance, storage locations have relocated to exploit differences in land value between urban retail precincts and peripheral land outside cities, while also

atomising freight flows into more frequent, smaller loads – effectively transferring the storage goods from private shops and warehouses to sitting in traffic on public roads (Rodrigue, Slack, & Comtois, 2001). Hence, simplistic notions of freight as being a basic service demand "derived" from broad economic activity have been questioned (Rodrigue, 2016), particularly since road freight activity has, in some cases, been observed to "decouple" with economic activity (McKinnon, 2007). The continual shifts in how firms work to service demand through moving goods is an inherent feature of freight transportation, which makes understanding both the present and potential futures of movement patterns difficult.

2.3 Misperception and False Equivalence

Cities and regions vary in their freight geographies, and many axiomatic concepts in planning should not be readily translated between contexts, or between different land uses. Cities themselves specialise differently, through the interdependency of the competitive specialisation of their hinterland regions, their urban agglomerations, and the infrastructure which connects them to wider markets. The specific characteristics of regional economics and their freight hubs gives rise to idiosyncratic advantages and cluster characteristics (Closs & Bolumole, 2015, p. 413). This may impede policy transfer between juristictions.

At a more local scale, the transfer of concepts between places and land uses may lead to similar error; for instance, firms select locations for highly divergent reasons. Through analysis of data for the United States, Sweet (2014) finds that only certain categories of firms are sensitive to congestion; businesses which directly serve consumers may be insensitive to congestion since their main concern is access to customers. Similarly, for some consumer-oriented retail and service industries, high transport costs discourage clustering, as firms disperse to service local consumers, whereas low transport costs incentivise firms to cluster together to yield the advantages of agglomeration (Holl, 2016). Some firms may be disadvantaged by closely located competitors, and thus may experience anti-clustering forces (Sweet, 2014). These dynamics are closely tied with the mobility of consumers in accessing commercial properties, illustrating the substitutability of passenger and freight trips at the consumer ends of supply chains. For these reasons, an increasing bulk of research is questioning the benefits of the axiomatic policy objective of reducing congestion at the end of supply chains (McLeod et al., 2019), where the impact of externalities might be most strongly felt.

3. Freight Planning Approaches

Conventional freight planning has been characterised by methods which seek to predict and then provide for freight movements, aiming to meet the expected needs of firms and consumers (Goulden, Ryley, & Dingwall, 2014; Vickerman & Monnet, 2003). One conceptual structure essential for such analysis is the classification of businesses and land uses - traditionally, categories of land uses have

formed the frame around which knowledge of planning for freight has been compiled and applied (Holguín-Veras et al., 2012, p. 38). A standard approach to freight planning is to collate quantitative reference data specific to land use classifications, which can then be applied to individual establishments or locations, using materials such as the ITE Trip Generation Manual, the TRICS database, or local sample trip generation rates (Transportation Research Board, 2003). These practices have often relied upon baseline reference material for understanding "typical" freight demands. These methods reflect positivist ontology (they assume freight can be known); they are technocratic (aiming to codify and mechanise knowledge through complex tools); and they depend upon the construction of analytical and conceptual structures which themselves reflect implicit values which may not be openly apparent (McLeod et al., 2019; Timms, 2008).

Land use classification is a potentially ineffective or inappropriate device for identifying the characteristics of an activity related to its potential transportation demand. This is evident through both the large variation between firms of the same categorisation (Holguín-Veras et al., 2011, p. 71), and in the inherent challenges of defining and translating land use classifications themselves. Planning jurisdictions typically have their own specific land use categories, which are themselves often different from the categories of types of businesses used to report data for other purposes, such as for taxation records. While there have been some attempts to translate land use categories between classification systems (Holguín-Veras et al., 2012; Lawson et al., 2012), there are often practical difficulties in their translation and therefore in the interoperability of data and insights between jurisdictions (Guttenberg, 1993; Joubert & Axhausen, 2011). To complicate matters further, individual sites may host several land use types, and land use types conceived in highly specific terms can be implicitly changed by the strategies and operating decisions of firms (Mentzer, 2004). The level of definition of uses is also important - more coarse or broad categories of land uses (e.g. "warehouse") may be easy to understand and discuss, but finer ones (e.g. "wholesale tyre distribution centre") may be more descriptively accurate, but harder to match to an adequate scope of reference information and available knowledge (Holguín-Veras et al., 2012).

3.1 Activity and Transport Demand Potential

There are several distinct measures of freight demand relating to land uses. Freight Generation (FG) describes the volume of goods created at a location; Freight Trip Generation (FTG) refers to the trips which move that material to or from that location, and Trip Generation (TG) describes all movements associated with a location, irrespective of trip type or purpose (D'Este, 2007; Holguín-Veras et al., 2011, p. 80; Iding et al., 2002). TG rates are the simplest and most common value associated with a land use commonly used in planning. Measurements of TG may capture *all* passenger and freight trips, but may reveal little about FG or FTG – except perhaps their logical maximum bounds. One conventional heuristic, recommended by the Institute of Transportation Engineers (ITE) Trip

Generation Manual (2012), is to estimate the percentage of FTG as a subset of TG as a basis for analysis (Lawson et al., 2012, p. 71). Increasingly, studies specifically reporting quantitative FTG are emerging (Iding et al., 2002; Lawson et al., 2012), though the pooling of results into wider reference databases and practice materials remains limited, especially when compared to existing work synthesising TG rates. The relationship between these measures, and the factors which influence them (drawn from the literature cited in this paper), is illustrated in Figure 1.

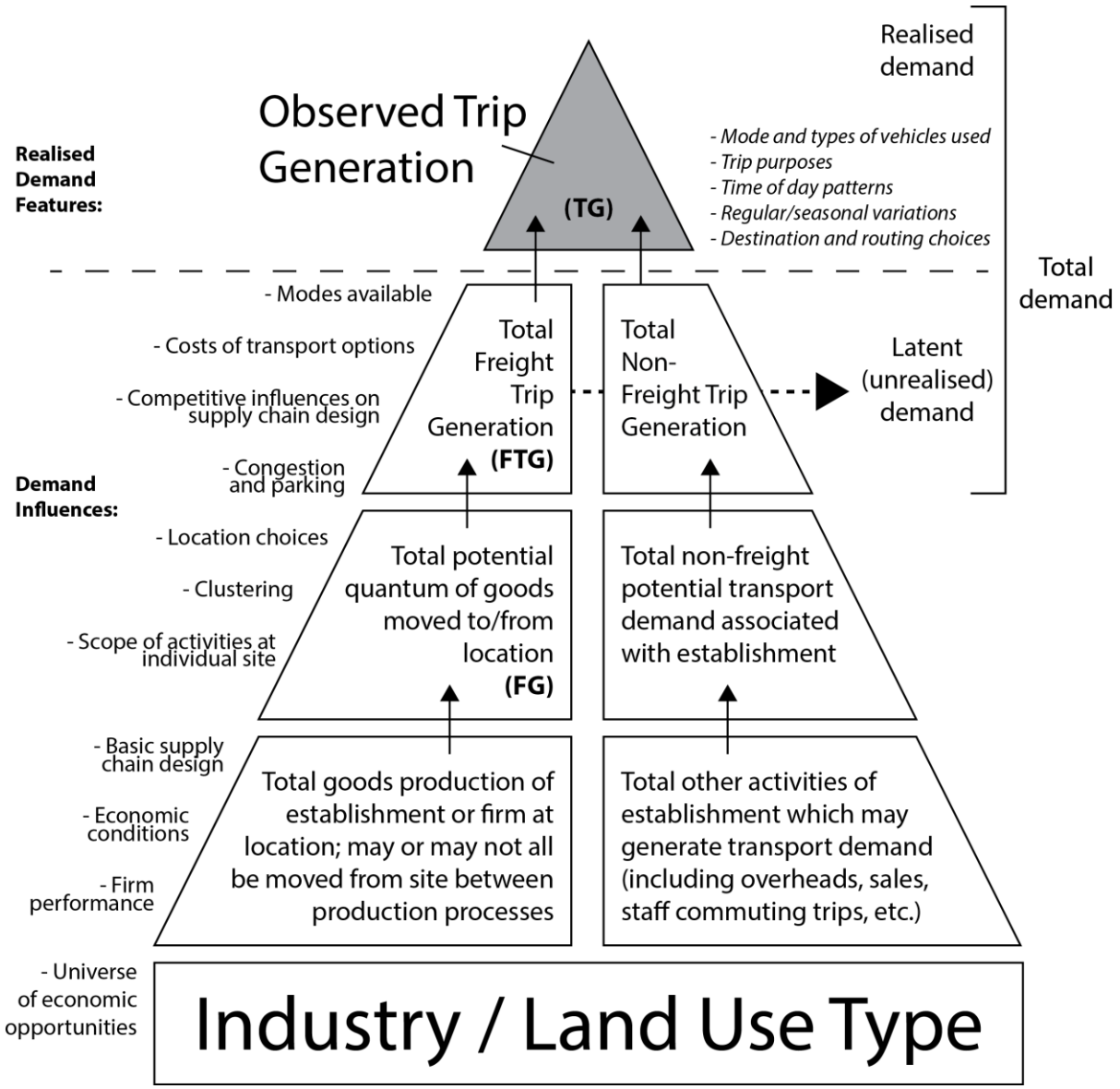

Figure 1: Conceptual Representation of Freight Transport Demand

While useful in basic traffic models and numerical analysis, reference TG rates themselves may offer limited insight into the actual nature of transport demands within a particular context. Reference TG rates may be measured to capture the most saturated examples of demand, which results in over-forecasting for real world development (Millard-Ball, 2015). Many freight related uses have seasonal or variable levels of activity and land use intensity through time, even if the zoning may remain the

same (D'Este, 2007). The realisation of observed trip generation depends on local policies which shape firms' access strategies, mode and vehicle choices, and daily patterns of operation (Cherrett et al., 2012; Muñuzuri, Larrañeta, Onieva, & Cortés, 2005). Considerable variation exists in TG between businesses of the same land use; often additional variables (floor space area, number of employees) are added in order to match observations to extrapolated values with a better statistical fit (Holguín-Veras et al., 2013). As is the case with passenger trips, freight trips may be realised (occurring and therefore may be observed), latent (not occurring due to limited available supply of capacity), or induced (occurring because improvements in transport supply results in realisation of additional trips); see (Vickerman & Monnet, 2003). Even if a magnitude of TG can be approximated, comparable firms or sites may have very different spatio-temporal characteristics of realised trips (Anderson et al., 2005, p. 81; D'Este, 2007), which themselves may be the root cause of problems, rather than the total magnitude of the demand itself.

3.2 Using Observations in Modelling

Modelling, particularly for planning at relatively local scales, often uses observed or reference quantitative TG values (such as expected vehicle movements for peak demand hours), typically in some form of extrapolation to forecast and plan for freight activity (Figure 2).

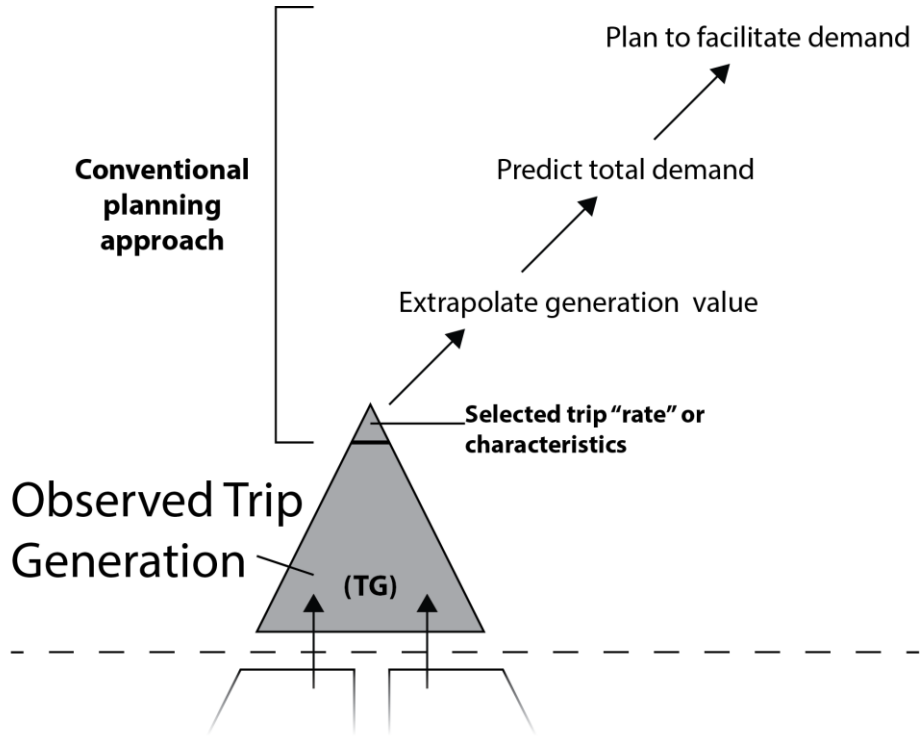

Figure 2: Conventional Extrapolation Approach Adapted from (Holguín-Veras et al., 2012, p. 111)

Modelling to support "predict and provide" approaches to freight planning without wider analysis of the nature of freight generation is likely to disregard the broad range of policy levers which shape

freight while engendering path dependent practices (Goulden et al., 2014). TG and FTG rates provide only a partial picture of how and why freight is generated; relying solely on analysis of quantitative data may distract from efforts to fully understand the underlying processes (Witlox, 2015). Increasingly, freight researchers have underlined the importance of pairing quantitative and qualitative methods of research to understand the base characteristics of freight demand, and the options for influencing them (Holguín-Veras, Amaya Leal, & Seruya, 2017; McLeod et al., 2019). In pairing qualitative and quantitative approaches to freight, planners must understand key features of the problems of practically understanding the generation of freight movements. They may then also apply available policy guidance and policies from elsewhere in a manner which is responsive to local contextual factors (Allen, Thorne, & Browne, 2007; Dablanc, Giuliano, Holliday, & O'Brien, 2013).

In contrast to statistical modelling approaches (Figure 2), planning for large bulk handling facilities for material flows at early stages of supply chains often places key logistics decisions much earlier in the analytical process (Table 1). For instance, in many forms of port demand forecasting, bottom-up identification of potential freight flow demands (such as for different commodities, industries, economic demands, etc.) is commonly used as a base for scenario and options analysis. This approach results in modal choice decisions being contemplated early in the planning process – in this way it is proactive, supporting the opportunity to select more sustainable options. In this sense, conventional four-step modelling could be understood as being passive to supply chain design, whereas a qualitative analytical approach aims to explicitly shape critical decisions which determine how freight flows become actualised early in the planning process. While this may already occur in the design of supply chains for bulk material flows, this process may also be applied to more proactively shape urban freight issued at the consumer ends of product supply chains.

Table 1: Conventional Modelling and Supply Chain Analysis Approaches

Conventional (Four Step) Modelling Approach	**Supply-Chain Analysis/Design Approach**
1. Calculate Trip Generation (Extrapolate TG value, forecast total demand)	1. Identify universe of market opportunities and their characteristics, and approximate FG scale for demand scenarios
2. Trip Distribution (identify origin and destination locations)	2. Identify supply chain designs, modes, and evaluate feasibility
3. Mode and Vehicle Choice (split between modal options). Note that this limited in urban freight planning as motorised road transport is often assumed.	3. Evaluate internal and external costs of resulting FTG or material handling (often through a formal Environmental Impact Assessment or Business Case)
4. Route Assignment (identify how vehicles will travel on networks, and predict and provide infrastructure accordingly)	4. Optimise and refine (often in conjunction with external stakeholders and actors)

For urban planners, the actual design of supply chains may be obscure, especially where freight planning problems are created by the aggregation of many different freight movements along a corridor. Evaluating individual supply chains may not therefore be feasible, though the evaluation of the key mechanisms through which TG is realised is a powerful framework for assessing and influencing freight transportation. This is illustrated in Figure 3, and suggests the need for a shift in focus from questions of *what* freight activity is currently occurring, to broader questions of *how* and *why* freight trips are generated - which may reveal wider insights which enable in more proactive and varied planning approaches. While planners may already hold such knowledge, often tacitly, it may be difficult to operationalise in the management of urban freight issues.

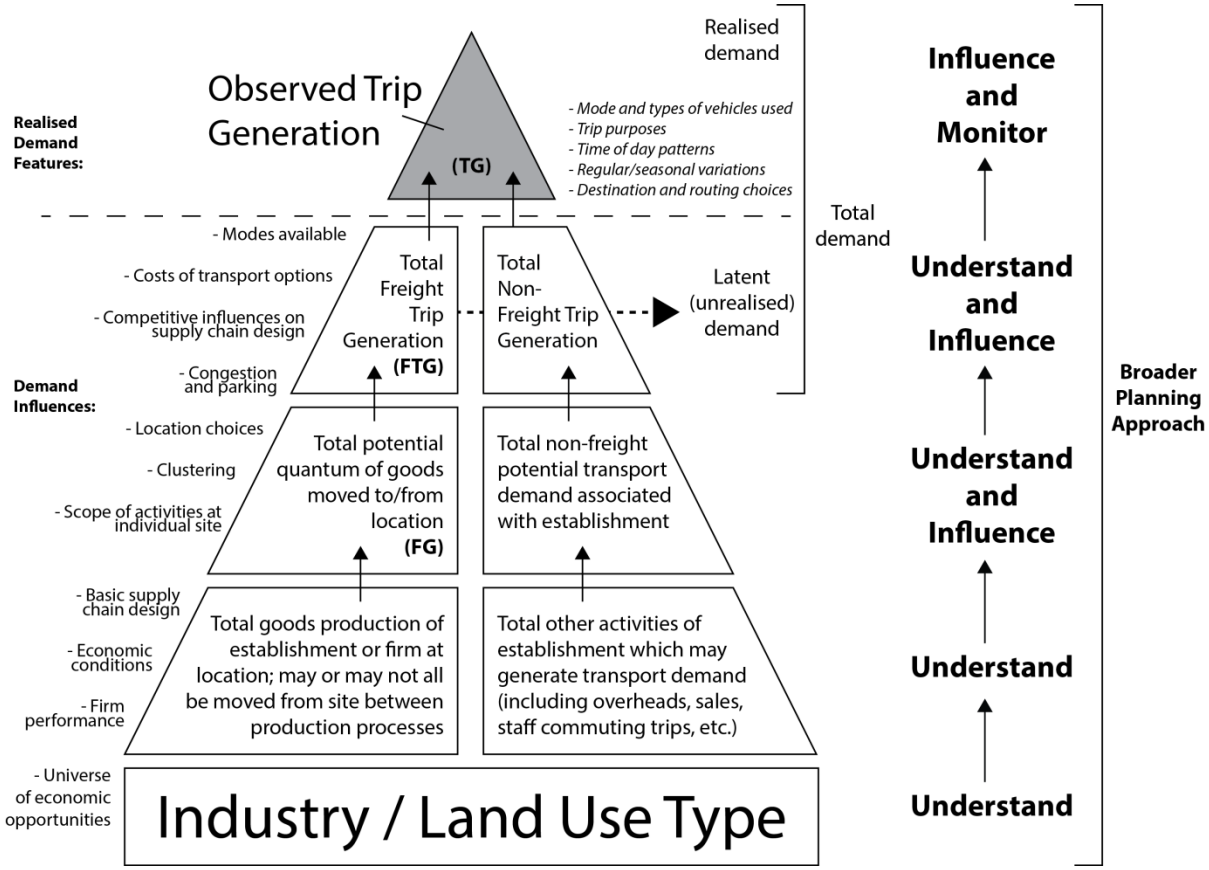

Figure 3: Understanding and Influencing Supply Chains in Planning

4. Understanding Freight by Supply Chain and Land Use Context

Recognising the complexity and uncertainty in conceptualising freight, there is a key need to understand the likely factors influencing specific FTG as specific stages of product supply chains, which can be mapped to broad categories of land use. With a specific focus on land uses at intermediate and later stages of supply chains (those more likely to be urban), this section collates thematic findings from the research literature to frame and inform the forces which influence FTG. These findings provide a basis for policy aimed at achieving more sustainable outcomes. We provide findings at broad thematic groupings of land uses to support planners seeking to understand the potential factors which may be sensitive to different planning policy approaches.

4.1 Early Supply Chain

Land uses at the start of product supply chains tend to involve the extraction of natural resources. Uses in this category include agriculture, mining, forestry, and other forms of primary production. To achieve feasible economies of scale or to access exceptional natural resources, such uses tend to be in rural locations. The movement of low value bulk commodities is cost-sensitive and typically involves large volumes, which supports lower per-unit operating unit cost modes of pipelines, shipping, conveyer belts, and railways (Vassallo & Fagan, 2006). In contrast, high value density raw materials

such as fresh seafood may have highly atomised, resource-intensive, and direct supply chains. Owing to the immense variation in these land uses, their typical location in regional or remote areas, and their limited FTG impacts within cities, these freight flows require specialised focus and are therefore beyond the scope of this paper.

4.2 Mid Supply Chain

As commodity products are prepared or transformed for end users, there are typically several transfers which occur through the middle of the whole product supply chain. These points are associated with economic activities which add significant value to materials and products (Bhatnagar & Teo, 2009). The associated cargo flows tend to involve large vehicles, large format land uses, and intermodal transfers, all to yield economies of scale. These freight flows may also be inter-regional or international, and politically significant due to the degree of economic activity they may be seen to support (Ogden, 1992).

4.2.1 Manufacturing, Processing and Fabrication

Manufacturing activity is typically characterised by the need to achieve and maintain scale and continuity of operations. Therefore, they are typically influenced by freight infrastructure accessibility (Holl, 2004), use heavy vehicles (Cherrett et al., 2012), are sensitive to land costs, and are often pushed to locate to low-cost distal locations, away from strict planning regulation (Ingram, 2016). These patterns of decentralisation have also coincided with the globalisation of manufacturing activities, which has generally resulted in greater supply chain complexity (McKinnon, 2009). Transport and land costs are significant in location selection, particularly with respect to storage. Where transport costs are low and relative differences in land value are high, atomized “just in time” supply chain strategies with centralised stockholding may be common (Allen, Browne, & Cherrett, 2012a). High transport costs or poor reliability may incentivise supply chains which increase local storage and the close co-location of related firms (Gulyani, 2001; Holl, 2016). Poorer transport conditions may also be associated with increased product specialisation, as firms facing higher freight costs may have to offer strong value differentiation (Mora & Moreno, 2013). Due to combinations of these effects, manufacturing industry uses are strongly inclined to form clusters (Sánchez-Díaz, Holguín-Veras, & Wang, 2014). Perhaps owing to their macroeconomic significance, manufacturing uses have been the subject of considerable freight research, and empirical TG studies (Institute of Transportation Engineers, 2012, p. 163).

4.2.2 Storage and Distribution

This land use class primarily encompasses logistics activities. These exist at intermediate points within supply chains, involving the transfer and modification of flows of freight. Such uses typically utilise large vehicles for aggregate or consolidated flows, with smaller vehicles for intermediate or “last leg” trips (Iding et al., 2002; Khan & Machemehl, 2017). Firms in this category are likely to

interact with ports and airports (Chhetri, Butcher, & Corbitt, 2014; O'Connor, 2010), and larger distribution facilities are almost certain to require the option to operate across the 24 hours of the day (Jakubicek & Woudsma, 2013, p. 168). To satisfy the demand for large expanses of preferable land, freight and logistics companies have also tended to relocate to distal low-cost locations, beyond the urbanised core of the city and more rigid planning controls (Allen, Browne, et al., 2012a; Cidell, 2010; Ingram, 2016; Verhetsel et al., 2015).

Far from being basic transfer points, these uses may support diverse innovative and adaptive business practices which add value to end consumers (Anderson et al., 2005). These uses have been disrupted significantly by retail delivery time competition, and the automation of internal warehousing functions (McLeod et al., 2019). There has been considerable research focus on the potential for more sustainable smaller distribution vehicles - including bicycles, electric vehicles, and public transportation services to carry such freight (Arvidsson & Pazirandeh, 2017; Baindur & Macário, 2013) - as well in the development of shared urban freight consolidation centres (Allen, Browne, Woodburn, & Leonardi, 2012). Further, increased online retailing has catalysed significant growth in distribution to local receivables points, such as post offices and parcel lockers (Edwards, Halldórsson, McKinnon, & Cullinane, 2010), from which consumers themselves retrieve deliveries. Such trends illustrate the blurry interface between land uses which may be considered "retail", "distribution", or "storage."

4.3 End Supply Chain

Freight delivered to the point of sale or to the end consumer – often referred to "last mile" freight – typically creates a large magnitude of negative impacts dispersed throughout cities and towns (Allen et al., 2018). These movements shift goods at their ultimate and highest value density, and therefore there is usually scope for the design of these flows to adapt to consumer needs or be shaped by policy (Browne, Allen, Nemoto, & Visser, 2010). Due to low barriers to market entry, relatively local movements at the ends of supply chains are typically moved by a wide range of operators using a variety of vehicles, competing in hotly contested markets (McLeod et al., 2019). This can make these flows extraordinarily fragmented and challenging to observe in totality.

4.3.1 Shop/Retail and Residential Deliveries

Retail land uses represent the final storage location of goods sold to the consumer, though recent increases in online sales and deliveries are significantly disrupting the nature of retail-related trips. Retail itself has transformed considerably over time, through changes in technology, urban structure, and consumer preferences. Food and groceries are a significant category of freight within the retail sector, particularly as many perishable products demand rigid and frequent delivery patterns (Khan & Machemehl, 2017; Muñuzuri, Cortés, Onieva, & Guadix, 2010). The nature of these demands incentivises suppliers to adopt very efficient supply arrangements (Boerkamps et al., 2000). Where

congestion is severe, suppliers may innovate to best exploit options and modes available. Baindur and Macário (2013) document complex intermodal food delivery networks operating within congested Indian cites, exemplifying the adaptive nature of delivering to end consumers. Retail uses tend to favour locations along busy road corridors (Holl, 2016), which may make them appear to be relatively insensitive to congestion (Sweet, 2014). Since many retailers must locate proximate to a catchment of local residents, they may require relatively high-cost land, which in turn discourages stockholding at the retail address, necessitating more frequent freight movements. This underlines the importance of considering land costs, direct transport costs, and external or indirect costs when evaluating consumer supply chains in the context of planning policy.

There are several policy approaches which may improve the sustainability of retail-related freight deliveries. Key strategies include consolidating distribution movements into larger, more efficient flows; deliveries may be required to occur at certain times or by certain vehicles; and passenger trips may be interchanged through policies which incentivise more efficient delivery strategies (Cairns, 2005; Marcucci & Gatta, 2017). Research attention has also recently focused on improving the sustainability of deliveries to homes, through reducing failed delivery attempts and by consolidating delivery and receival points (Cherrett et al., 2017).

4.3.2 Construction and Service Industries

Construction and service industry logistics have significant and often highly variable impacts within cities. Traditional land use classifications and quantitative assessments of freight may not readily integrate construction as a temporary land use on sites which are zoned according to their ultimate purpose, and freight-related construction data may be reported at the address of company headquarters, rather than at worksites (Jaller, Wang, & Holguin-Veras, 2015). The fragmentation of contractors involved in construction can also complicate research, as each sub-contractor is essentially a micro-scale freight provider (Rashidi & Roorda, 2017). The distribution of worksites also changes through time, which may hinder efforts to translate past observations into forecasts. However, the concentrated impacts of construction traffic and the considerable opportunities for increased efficiency does incentivise careful planning of construction logistics, especially in constrained inner-urban areas (Sullivan, Barthorpe, & Robbins, 2011). The shared opportunity to increase construction efficiency while simultaneously reducing impacts within cities supports collaborative planning by industry and regulators (Hesse, 2007).

Several other categories of land uses within the service sector may generate freight demands which may be poorly understood. Vehicles used to support the delivery of services are a significant set of non-passenger transport demands, though they may not be readily perceived as being “freight” (Ellison, Teye and Hensher, 2017). Office uses also have varied freight and service delivery demands, though often only TG reference information is available. Freight to offices is typically through many

different operators using small vans or passenger vehicles (Cherrett et. al. 2002, quoted in Cherrett et al. 2012, p. 26). The freight flows associated with these categories have received comparatively little research attention.

4.3.3 Waste

Waste occurs at virtually all land uses and at every point along supply chains (Cherrett, Maynard, McLeod, & Hickford, 2010; McLeod et al., 2019). These flows range from high value unopened products being returned to sellers, to unwanted products and materials which may represent a resource, and finally to noxious wastes with no potential for productive use and high disposal costs. "Reverse logistics" is now widely described as the practice of managing these flows, through measures to reduce the creation of reverse flows through product design, and through the efficient handling and maximum recovery of resources embodied within waste flows generated by end users (Carter et al., 2011). Key freight policy measures for managing waste freight include the potential use of spare freight vehicle capacity for reverse logistics - known as "backloading" (Vickerman & Monnet, 2003); the coordination or consolidation of fragmented waste collection, servicing, and other freight flows to reduce total trip volumes (Browne, Sweet, Woodburn, & Allen, 2005); and the broader design of products and services to form "closed loop" systems with little or no unrecovered resources (Cherrett et al., 2010). Hence, waste essentially needs to be considered as a specific (reverse) freight flow for virtually all land uses.

5. Conclusions

Freight trip generation is inherently complex and dynamic. As governments worldwide aim to manage freight towards more sustainable outcomes, much of the reference literature designed to facilitate prediction and accommodation of FTG offers little insight for how freight can be managed to reduce impacts on societies, economies, and environments. For planners working to address complex, often value-laden freight policy issues to meet public interests, quantitative trip and freight trip generation rates provide limited insights into factors which determine how freight moves within cities. Similarly, freight modelling may offer an incomplete perspective of likely freight distribution for inherently uncertain futures. Aside from observations of trip demands themselves, planners must consider the challenges to enacting freight policy (section 2), the limits of conventional freight analysis (section 3), and the complex factors that influence freight at different stages of supply chains (section 4). Some of these considerations may challenge quite foundational constructs in the practice of planning, particularly in the codification of land use and in the transferability of observations between places. These issues - and growing interest in understanding how to plan for freight to meet both economic development and sustainability goals - has seen new interest in mixed-methods planning, yielding a growing corpus of freight policy literature. The strong evidence for adaptability within supply chains should be of particular interest in transitioning from 'predict and provide', towards planning

approaches which aim to achieve multiple public interest objectives through the proactive management and collaborative shaping of actual FTG.

Freight research is inherently challenging and resource intensive, as is the development and application of freight policy. It is clear, however, that practitioners and researchers need to focus attention on how and why FTG occurs to more effectively plan for it. Many resulting policy interventions may offer benefits for private sector operators, governments, and the public more broadly, especially where improvements in operational efficiency can be achieved. The use of theory, best practice guidance, qualitative framing devises, and insights from stakeholders across freight industries is critical in enabling planners to develop an informed picture of the underlying drivers of freight (see Figure 3), which may then be influenced to achieve improved freight sustainability. This knowledge must be accreted locally, contemplated and analysed both in terms of land use types, and in the context of supply chains.

While the existing published knowledge offers key insights into freight in certain places and times, the authors of this paper concur with Cui et al. (2015) in emphasising an urgent need for the freight research literature to be more available to practitioners creating and operationalising planning policy, especially in differing practice contexts. While the related fields of transport modelling, economics, and logistics have developed a body of research, and while there is a growing community of freight policy researchers, there remains significant potential for a richer interface between freight planning research and current policy and practice. We contend that planning practitioners ought to more frequently offer insights to the profession through the publication of case reports, more extensive sharing of data and information, and in the institution of freight as an important field of practice within the domain of planning. Key to this should be additional focus on the policy, political, and institutional processes and practical methods for integrating both differing knowledge and divergent values to improve planning for freight. While commercial sensitives may and should, to a degree, temper the full disclosure of freight related insights, planning practitioners retain a duty to our practice and the public to build and share knowledge to support improved outcomes in the way we manage freight within cities. Achieving effective and sustainable outcomes for freight transportation as conventional practice will depend on a much richer dialogue within and across communities of planning.

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