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Computationally Simulating Intermodal Terminal Attractiveness and Demand

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Abstract: The use of open data to analyse and model freight movements has been quite limited till date. This is mainly due to the shortage of open data focusing specifically on freight movements across cities, regions or countries. Here we leverage openly available government data to enrich and further analyse commercial data to develop a flexible and dynamic tool enabling Intermodal Terminal Operators to forecast demand, set prices and in turn maximise their profitability.

Keywords: modelling transport networks, whole-city computational model.

Introduction

Inter-modal terminals (IMTs) reduce road congestion and exploit economies of scale by pooling demand and using rail to transport containers to and from ports. The alternative to IMTs is using trucks[1] to transport directly to port. Trucks increase road congestion but rail requires additional handling of containers (lift on and lift off). The attractiveness of truck versus rail is dependent on a number of variables such as cost, total travel time, frequency of services, risk etc. Currently IMT operators and policy makers make decisions on a coarse-grained level. We aim to build a dynamical tool that leverages open and commercial data to enable various stakeholders like IMT operators, port authorities and government policy makers to make more informed decisions.

Here we simulate the operations of IMTs and demand for containers in the greater Sydney region. Our objectives are to improve the efficiency and profitability of IMTs. This is performed through modelling to predict profit based on different asset mixes (trucks vs. rail) and pricing structures. We develop a value-driven modelling framework that incorporates: (i) a detailed IMT operational model capturing costs, capacities and service times for different asset mixes; (ii) demand forecast model (in progress); (iii) competition from other offerings e.g. other IMTs or direct truck transport (in progress). The component models are calibrated to internal operational data and publicly available geospatial data.

We model the internal optimisation of the operations and assets within an IMT to maximise return on investment for IMT operators. The value of these simulations is to conduct what-if scenario analyses to allow the outcome of different investment and operational decisions to be more accurately predicted.

[1] Barges are also an alternative but not applicable in Australia

Model Description

Our model is composed of the following components: 1) Demand model. We simulate aggregate container transport demand at the suburb level based on available data. 2) Decision model. Import and export customers within each region have the choice of trucking containers directly to the port or trucking to an inter-modal terminal (IMT) after which the containers get transported to the port on rail. We assume that customers choose the cheapest of the options of IMT or direct truck to port and hence the retail train price determines the overall demand from the greater Sydney region. 3) Competitive price structure. The cost of directly trucking to port is a zone-based commercial model that implicitly takes travel distance into account.

Our model couples asset mix (capacity and operation costs), which determines the cost in operating an IMT and the retail pricing of trains (charged to customers). We focus on non-vertically integrated container supply chains, where IMT operators control rail and road operators control truck movements and prices.

Results

Our tool allows IMT managers to perform a "what-if" analysis by choosing a particular retail price (covering train movements) and a particular operational configuration (asset mix). It then enables them to predict the overall throughput and to quantify the overall revenue and return on investment of the IMT operator under study. Furthermore the tool can calculate the optimal retail prices enabling the IMT operator to maximize its overall profitability. We observe that there is a range of train prices between which operation of an intermodal terminal is profitable (Fig. 1). The costs of different investment and operational decisions of how frequently IMT operators run trains (dotted lines, Fig. 1) is shown with the expected demand for containers that can be expected from the region.

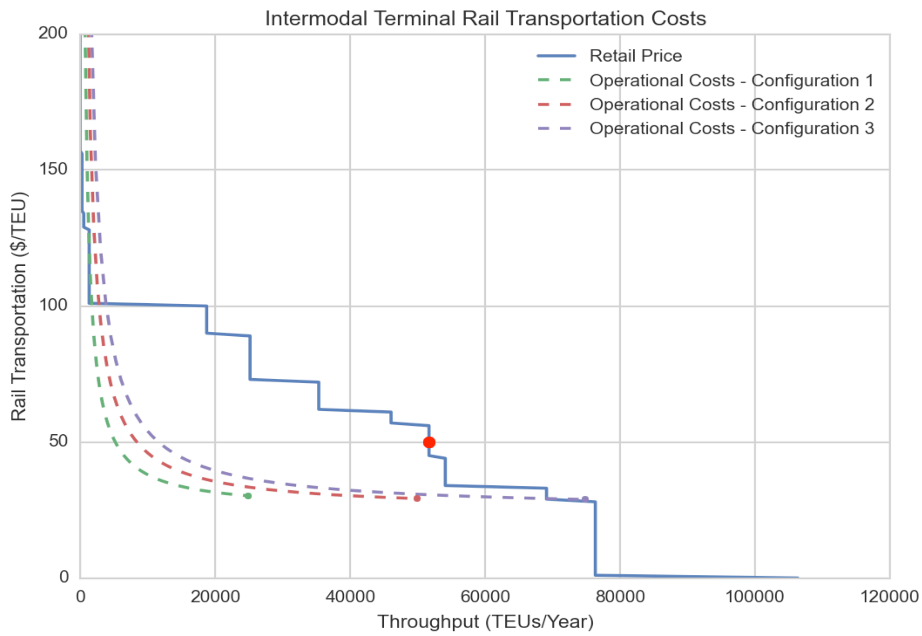

Figure 1. Plot of offered rail transportation price (blue) and operational costs incurred by IMTs (dotted lines) vs. demand for containers. The red dot marks a rail price ($50/TEU) offered by IMT operators (to customers) that make the IMT profitable.

Our simulations also predict which regions in the Sydney metro region would use the Enfield IMT for a particular train transportation price (Fig. 2, left panel) and the cost difference between customers using an IMT vs. direct truck (Fig. 2, right panel).

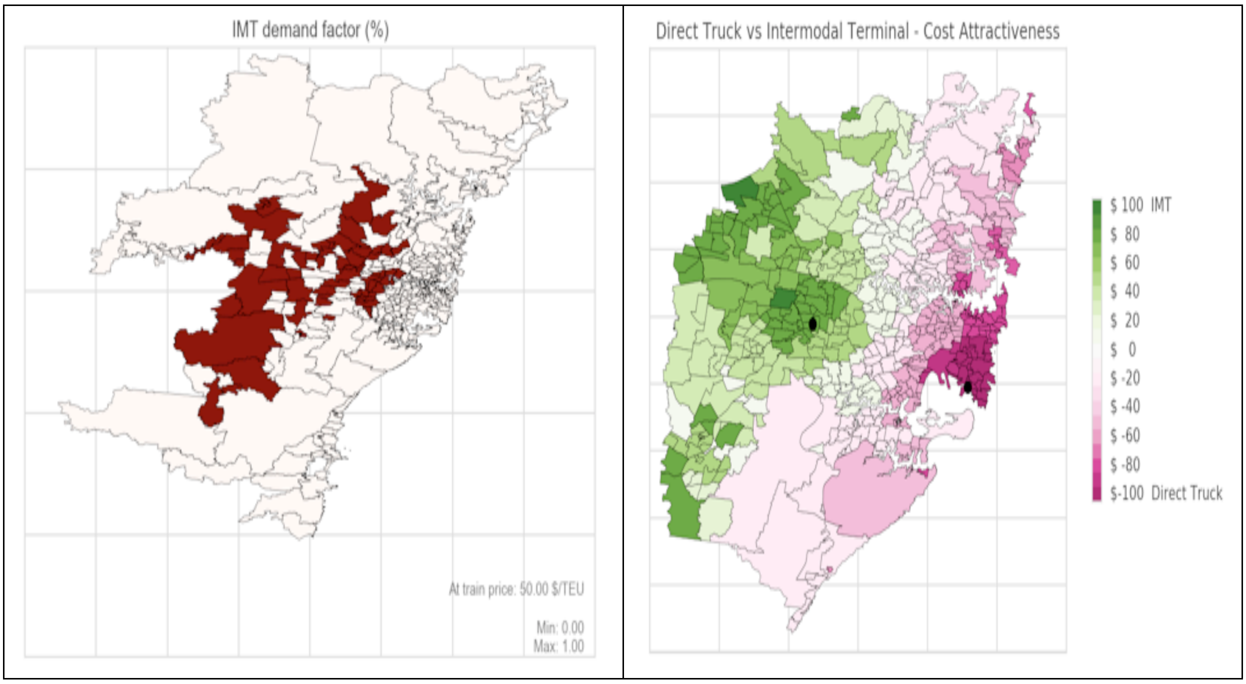

Figure. 2. Left panel: Map of regions using Enfield IMT for an IMT train transportation price of $ 50/TEU (simulated). Right panel: Map of regions coloured by cost difference between using IMT vs. direct truck

Discussion

Here we leverage openly available government data and commercial data to show how we can implement intelligent transportation, logistics and decision mechanisms for terminal operators. This would reduce costs, reduced miles driven on road and lead to reduction in vehicle emissions. In the future we plan to incorporate socio-economic data to generate accurate models of demand. The present work shows how we can leverage open data to drive innovation and deliver value to businesses. We hope this will be the first step towards whole-city computational models that can be used by businesses, government and policymakers to create more value in cities. We aim to integrate large amounts of open data with commercially available data to build a tool that will enable business, government and policymakers to make informed decisions. We expect the tool to be automated (changing as critical parameters such as truck speed and congestion change daily) and dynamic in order to respond to the ever-changing needs of businesses.