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Estimation of the full marginal costs of port related truck traffic

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ABSTRACT

NY region is expected to grow by additional 1 million people by 2020, which translates into roughly 70 million more tons of goods to be delivered annually. Due to lack of rail capacity, mainly trucks will haul this volume of freight, challenging an already much constrained highway network. What are the total costs associated with this additional traffic, in particular, congestion, safety and emission? Since a major source of this expected flow is the Port of New York–New Jersey, this paper focuses on the estimation of the full marginal costs of truck traffic resulting from the further expansion of the port's activities.

1. Introduction

In large metropolitan areas freight transportation constitutes a significant proportion of all traffic, which in some corridors can reach over 25% of total flow. In global gateway cities, like New York, a substantial proportion of all freight movements are port related, which travel to hinterland locations and markets. In many cases rail captures a small share of these total freight traffic, whereas trucks constitute the main mode. This is certainly the case of the Port of New York and New Jersey (PNYNJ), where the limited availability of rail capacity is a major transportation constraint. There is also some barge operation, using coastal or inland waterways to haul balk and fuel commodities.

The contribution of the port to the region's economy is quite substantial, which explains why decision makers inclined to support plans aiming at expanding the port's infrastructure. In NY it has been estimated that the port's freight activity contributes annually about $18 billion in economic activity and $2.2 billion in tax revenues. For the past decade, international trade, mainly between the Far East and the US and Europe, has been growing at an average rate of 7% annually, which requires further investments in port facilities to handle the expected freight volume growth.

Against this reality we need to also consider societal costs of port expansion plans and the traffic pattern it generates. These costs can be categorized as: private (or internalized) costs, infrastructure investment and maintenance costs, and social (or non-internalized) externality costs. Jointly, in this paper they are labeled as full marginal costs (FMC) resulting from increased truck traffic.[1] The underlying argument is that these costs must be considered when assessing port capacity investments aimed at accommodating additional trade, so that correct cost-benefit analysis of these investments can be carried out. Thus, the main objectives of this paper are to identify and measure local FMC, associated with the annual addition of traffic engendered by port development. In this paper I disregard what would happen to FMC if port investments were not made and freight, therefore, would enter the New York region via outside ports.

The structure of this paper is as follows. Section 2 presents categories of FMC costs associated with increased truck traffic. The methodology used to estimate these costs is presented in Section 3. Section 4 provides basic data on freight movements through the Port and the NY–NJ metropolitan area. The data used in this study is discussed in Section 5 and major results are shown in Section 6. Section 7 outlines some possible policy approaches to reduce these costs. Summary and conclusions are in Section 8.

2. Societal costs of port related traffic

2.1. Cost categories

The main cost categories used to estimate the FMC from additional truck traffic are: (a) private costs, which include vehicle operating costs and own congestion costs; (b) infrastructure costs, which include capital and maintenance costs; (c) non-internalized externality or social costs, which include congestion costs, accident costs and environmental costs from noise and emission. These are defined as follows (see Ozbay, Bartin, & Berechman, 2001; Ozbay, Bartin, Yanmaz-Tuzel, & Berechman, 2007).

2.1.1. Private costs

2.1.1.1. Vehicle operating costs. These are costs borne by users. They include fuel and oil consumption, expected and unexpected

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[1] Mainly for lack of proper data in this paper I focus on local environmental costs and disregard climate change and global warming effects. For such effects see, for example, the Stern report (2007).

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maintenance, car wear and tear, insurance, parking fees and tolls, and automobile depreciation. Total vehicle operating costs are assumed to be a linear function of "total miles traveled", which, in turn, are highly correlated with the age of the vehicle. Additional truck traffic on the New York–New Jersey congested highway network is expected to lengthen car distances and times. That is, as traffic flow rises trip-makers are forced to switch to less congested but longer routes thus higher travel times.

2.1.1.2. Own congestion costs. Congestion cost defined as the time-loss due to traffic conditions and drivers' discomfort that trip makes endure, both of which are a function of increasing volume to capacity ratios. In Fig. 1, at traffic volume travel Q_1, the private congestion cost is P_1 (where the demand function D_1 intersects the average cost curve AC). When the demand function D_1 shifts to D_2 the new travel volume is Q_2 and the private congestion costs are now P_3. The difference: $P_3 - P_1$ represents the own congestion costs.

These costs are in units of time and are determined through the use of a volume-capacity function (AC in Graph 1), and their magnitude depends on the distance between any OD pairs (d), traffic volume (Q) and roadway capacity (C). To transform travel time changes into monetary value we use of value of time (VOT) ($/h).

2.1.2. Investment and maintenance costs

Roadway investment and maintenance costs are equated in this analysis with depreciation costs (3% per annum) and resurfacing costs. For lack of adequate data, below it was assumed that the marginal resurfacing cost equals the average cost.

2.1.3. Non-internalized externality or social costs

2.1.3.1. Non-internalized congestion costs (congestion externality). - From Graph 1, at traffic volume Q_1 the non-internalized social congestion costs are given by $P_2 - P_1$ (where volume Q_1 intersects the marginal social cost curve, MSC, less the private costs at this volume, P_1). When demand shifts to D_2 traffic volume increases to Q_2 and the social costs now are given by $P_4 - P_3$. Eq. (3) below shows these relationships formally.

2.1.3.2. Accident costs. Accidents were categorized as fatality, injury and property damage accidents. Accident occurrence rate functions for each accident type were then developed. Historical data obtained from NJDOT shows that annual accident rates, by accident type, are closely related to intensity of traffic volume and roadway geometry. Thus, in this study both intensity of traffic volume and the geometry of the highway network were considered.[2] Three accident occurrence rate functions were used one for each accident type and for each of three highway functional types. Hence, nine different functions were developed in total. Regression analyses have been used to estimate these functions.

2.1.3.3. Environmental costs. Environmental costs due to highway transportation are categorized as air pollution and noise pollution costs. *Air pollution* costs were estimated by multiplying the amount of pollutant emitted from vehicles by the unit cost values of each pollutant. The major pollutants including volatile organic compounds (*VOC*), carbon monoxide (*CO*), nitrogen oxides (NO_x) as directly emitted pollutants, and particulate matters (PM_{10}) as indirectly generated pollutant (for details see Ozbay et al., 2001). In this study only the local effects were included, though air pollution has trans-boundary or even global attributes.

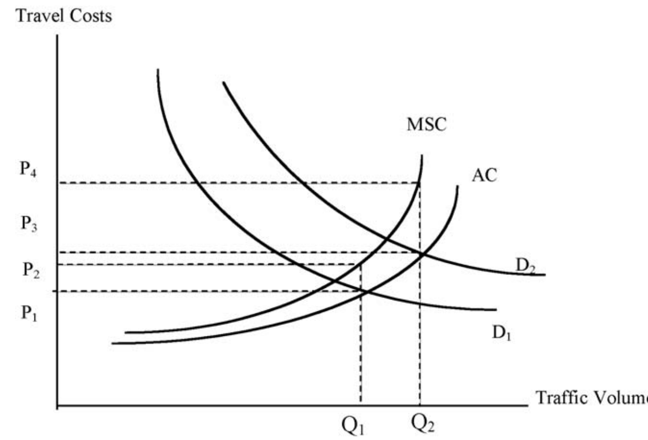

Fig. 1. Private and externality costs of traffic congestion.

Noise costs are most commonly estimated as the depreciation in the value of residential units alongside the highways. Presumably, the closer is a house to the highway the more its value will depreciate. While there are other factors that cause depreciation in housing values, "closeness to a noisy highway" is most often utilized as the major explanatory variable of the effect of noise externality. The marginal noise cost function is specified so that whenever the ambient noise level at a certain distance from the highway exceeds 50 decibels, it causes a reduction in the value of houses located within this distance. Thus, the noise cost depends both on the noise level, distance and the initial property value (detailed information is presented in Ozbay et al., 2001).

3. Methodology for measuring the full marginal social costs of truck traffic

To estimate Full Marginal Social Costs from additional truck traffic, it is necessary to define specific cost function models for the above cost categories. Beginning with congestion costs, Eq. (1) defines the cost of a trip between each specific OD pair:

$$C_{rs} = F(V_j; q) \tag{1}$$

In (1) q denotes travel volume between the OD pair r and s, and $F(V,q)$ is the average cost function, where V_j is a set of supply variables (e.g., capacity). For an OD pair (rs), total Cost (FTC) of providing transportation for q trips is:

$$FTC_{rs} = q \cdot (C_{rs}) = q \cdot F(V_j; q) \tag{2}$$

For each OD pair the marginal costs (MC) is:

$$MC_{rs} = \frac{\partial(q \cdot F(V_j; q))}{\partial q} = F(V_j; q) + q \cdot \frac{\partial F(V_j; q)}{\partial q} \tag{3}$$

This function (3) defines the cost of an additional trip in the system. The first term represents the private average costs ($P_3 - P_1$, in Graph 1). The second term: $q(\partial F(V_j;q)/\partial q)$ represents the externality congestion cost ($P_4 - P_3$, in Graph 1). Assuming users' cost minimization behavior, when travel demand between a given OD pair increases, travel patterns on all routes in the network will change as will all of the other cost components discussed above. Thus, to correctly estimate the magnitude of these effects measurements must be made at the network level using appropriate assignment algorithm (see below).

[2] To that end, highways were classified on the basis of their functional type, namely Interstate, Freeway-Expressway and Local-Arterial-Collector. It was assumed that each highway type has its unique roadway design features. This classification makes it possible to work with only two variables: average daily traffic volume and road length. This approach is also consistent with previous studies, e.g., Mayeres, Ochelen and Proost (1996).