A simple model of the choice of transport mode and plant location

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Abstract. This paper tries to ascertain whether or not the profit-maximizing transport mode will be different from the welfare-maximizing one, and investigates the impact of endogenizing the choice of transport mode on the choice of location and input usage. It is shown that the results derived are critically dependent on the characteristics of the chosen production function as well as the specification of the transport cost structure. The model is particularly relevant in countries such as Taiwan, where transport regulation can play a crucial role in determining the location and output of certain industries.

I. Introduction

Since Weber's (1929) pioneering work, there has been a growing interest in the transportation aspects of firms' location problems.\textsuperscript{1} In the traditional models of plant location, transportation facilities are considered as a major location factor and the minimization of the total transportation cost may be regarded as a basic objective. To date, what is surprising is that location theory has neglected some essential characteristics of transportation activity.\textsuperscript{2} For example, transport rates are assumed to be constant and/or transport rate structure is taken as exogenous within the models. This simply implies that only one mode is available. This assumption is unrealistic insofar as a firm generally, has many different kinds of transport modes to choose from — it can have its output delivered by sea, air, rail or road. Since the transport rate structure of each model differs, as long as the


\textsuperscript{2} Recently, Louveaux et al. (1982) have considered the problem of locating one firm within a transportation network and discussed some characteristics of transportation activity in detail. However, they did not consider the problem specified in this paper.
transport mode is treated as a decision variable, decisions should be made in the light of an internal trade-off between production costs and transportation costs.\(^3\)

The question of selecting the best transport mode and/or transport rate structure for an industry is being considered increasingly often as a "project" or "planning" by a government agency rather than as a profit-making venture by a private corporation. Because such planning problems must be resolved within the bounds of certain resources, it is important to evaluate the social desirability of alternative modes. In order to operate transportation activities efficiently, a government that has the objective of maximizing social welfare has an incentive to regulate transport modes or transport rate structures. It is worth mentioning that the efficacy of government policy may arise from the assumption that a government can credibly commit itself to the choice of transport modes before the location and production decisions are made by private firms. Specifically, the government becomes the first player in a two-stage game and can influence the equilibrium location and production outcomes of the game played by private agents by altering the set of transport modes open to them. It is apparent that the welfare-maximizing model chosen by the government may be to some extent different from the profit-maximizing one selected by a private firm, so that the equilibrium location and production outcomes of a private firm are affected dramatically. In this setting, transport regulation can play a crucial role in the determination of the location as well as the output of the industry. This kind of regulation has been used in some developing nations.\(^4\) For example, in Taiwan, the central government builds a highway for a local petroleum company to encourage it to transport oil by truck. It also constructs a railway system to attract cement manufacturers to locate their factories in the North-East region of Taiwan and to transport their product by railway. The main purpose of these regulations is to affect (or guide) industrial location. But the locations, if optimally chosen, can lead to a situation in which the price and output of the product concerned means the society is better off. However, to our knowledge, this important issue has not been examined in the literature. Our paper is intended to extend the traditional location models by considering the decisions on transport mode, production and location simultaneously within a simple framework.

The aims of this paper are (i) to develop a model which allows the issue of the best transport model to be addressed; (ii) to compare and contrast (in purely theoretical terms) the implications of the profit-maximizing transport mode with those of the welfare-maximizing mode; and (iii) to demonstrate that under certain assumptions the profit-maximizing transport mode is equivalent to the welfare-maximizing one, and so are the location and input usage.

In the analysis presented here, the input usage (and hence output), the location and the transport mode of output will be treated as choice variables. Moreover, we examine a subgame perfect equilibrium in a two-stage game. In the first stage, the transport mode of output will be determined using both profit-maximization

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\(^3\) The spatial pricing model with an endogenous transport rate was hinted at Beckmann (1976) and developed by Gronberg and Meyer (1981, 1982).

\(^4\) We are indebted to a referee for raising this interesting point.