Private Road Network with Uncertain Demand

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Abstract

We study how private firms compete to build roads in a network with demand uncertainty. In an initially untolled network, private firms can sequentially add a link to it, set capacity of the link and charge a toll on it. Since road construction takes time, the demand is not known for certain when they make the capacity decision. After the road is built, the uncertainty is resolved and the tolls are set. After several rounds of link addition, how does this demand uncertainty influence the final network structure and resulted congestion? How can regulation help to achieve better results than oligopoly competition? These are the questions we investigate in the paper.

To model it, we start with a simple network with only one origin-destination pair and two segments connecting them, similar to Verhoef 2008. Each round one link is added in either segment. Demand can be high or low, which capture the unpredictable future economy state

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at the time of road construction. Private firms sets the capacity of the added link when demand is unknown. After the road is built and the demand is known, all firms in the network sets tolls simultaneously. Then a new round of link addition begins. We assume that in each round, firms rightly anticipate the following toll setting equilibrium when choosing capacity. But they think every round is the last round, to simplify the analysis.

We calculate the first-best and second-best-zero-profit equilibria of the game as benchmarks. Then we compare them with the equilibria using various auctions to allocate the link, including maximum patronage, minimum toll and so on.

To solve for each equilibrium, we use computer simulation. For each round, we first solve the Nash equilibrium in the toll setting stage, then using that information to determine the capacity setting. A new round begins with the result from the previous round.

We are working on the simulation now and expect the maximum patronage auction to achieve the same result as the second best zero profit equilibrium. We also expect overinvest in capacity due to the convexity of the problem.

The related literatures are amongst others Verhoef 2008 (Private Roads: Auctions and Competition in Networks) and Proost and van der Loo 2010 (Transport Infrastructure and Demand Uncertainty).

**Keywords:** Uncertain Demand, Network, Auction, Private Road, Competition