The Economics of Intersections

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1. Problem and research questions

This paper takes an economist's perspective on the road intersection problem, an issue traditionally studied by engineers. We consider an intersection of two roads connecting one origin-destination pair and address questions related to the optimal regulation of this intersection, e.g. :
-Is it more efficient to regulate the intersection by traffic lights or by a priority rule?
-What are the main drivers of the optimal signal setting?
-How is the optimal toll affected by the signal settings?
-How are the optimal signal settings affected by a change in the elasticity of demand?

2. Methodology

We analytically minimize total travel cost, taking into account Wardrop's principles and the delay at the intersection. Different types of routes and different modes of transport are studied by distinguishing between roads/modes that are congestible and roads/modes that are insensitive to congestion. We first consider fixed demand and subsequently extend the problem to include elastic demand.

3. Major findings

-If the intersection of two routes connecting one OD-pair is regulated by a priority rule, it is in general optimal to block one of the two routes. The only exception is the case where the marginal congestion cost on the minor route is greater than half of the square of the marginal waiting cost. In that case, a solution in which both routes are used can be optimal.
-If the intersection of two routes connecting one OD-pair is regulated by traffic lights, and only one route is congestible it is again optimal to block one route. However, when both routes are congestible or a toll is levied it can be optimal to use both routes.
-If both routes are congestible the optimal signal setting is independent of the total flow and identical for both inelastic and elastic demand.
-If only one route is subject to congestion, the likelihood of the superiority of a regulation by traffic lights over a priority rule increases with the flow on the main route and the cycle time, and decreases with the response time of the drivers.

4. Takeaway

Both the situation where the intersection is regulated by a priority rule and the situation where the intersection is regulated by traffic lights yield some interesting takeaways:

-If the intersection is regulated by a priority rule, it is almost always optimal to block one of the two routes.
-If the intersection is regulated by traffic lights, the optimal signal setting is always independent of the elasticity of demand.

5. **Keywords**
   Signal setting, priority rule, road pricing, elasticity of demand

References

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