Title

Hotelling Location Problems with Directional Constraints: An Application to Television News Scheduling

Authors
Cancian, Maria
Bills, Angela
Bergstrom, Ted

Publication Date
1995-03-01

Peer reviewed

THE JOURNAL OF INDUSTRIAL ECONOMICS 0022-1821 $2.00
Volume XLIII March 1995 No. 1

HOTELLING LOCATION PROBLEMS WITH DIRECTIONAL CONSTRAINTS: AN APPLICATION TO TELEVISION NEWS SCHEDULING*

MARIA CANCIAN, ANGELA BILLS AND THEODORE BERGSTROM

If viewers prefer to watch the news as soon as they get home from work, how should competing television stations schedule their broadcasts so as to maximize the number of viewers? Given a Hotelling location problem with a directional constraint (viewers can watch any time after they get home, but not at all before), we show that there exists no pure strategy Nash equilibrium.

I. INTRODUCTION

CONSIDER the problem of sheduling evening television newscasts: each network must decide at what time to locate its show so as to maximize audience size. If viewers watch the first newscast shown after they return home, a single (monopoly) network clearly maximizes audience size by scheduling its broadcast as late as possible; it thereby captures the entire audience for the news program. If two stations broadcast the evening news, they will each try to schedule their programs as late as possible (to maximize potential audience size) while still being the first station to air its program (so as not to lose potential audience to an earlier broadcast). We show that generally in this situation there is no pure strategy Nash equilibrium solution since each station will respond by moving its broadcast to start just before its competitor's.

II. THE MODEL

These results contrast markedly with those of the standard location problem. Recall the problem of a hot dog vendor who must choose a location on a strip of beach. Customers are evenly spaced on the beach. No matter where the hot dog vendor locates, if there is no competition, the vendor will get all of the customers. To minimize the mean distance traveled by each customer (and to maximize the number of customers, if some people will only walk a certain distance) the hot dog stand locates in the middle of the beach. Given two vendors, both choose to locate in the middle of the beach. While there is no set of locations for three vendors that constitutes an equilibrium, four

* The authors thank participants in the Micro Theory and Industrial Organization Seminar at the University of Michigan, the BEER Seminar at the University of Michigan, especially Theresa Greany, and anonymous referees, for helpful comments on earlier drafts.

vendors will move such that two are located at the 1/4 point and two at the 3/4 point (Hotelling [1929]).

Why are the solutions to these two similar cases so different? The key factor in the case of newscast scheduling is that viewers can only watch shows that begin *after* they have returned home from work. In contrast, we assume that hot dog buyers only care how far they will have to walk, not in which direction. In the case of news broadcasts the "directional" constraint has significant implications for the existence and nature of equilibria.

Continuing with the example of news broadcasting, let us assume that stations choose their broadcast time in order to maximize audience size, on which advertising revenues depend. Further, assume that viewers watch the first program that starts after they get home from work. If the audience is given a choice between k broadcasts that are shown simultaneously, each station only captures the fraction $1/k$ of the total relevant audience. Thus, a station's profit depends not only on its location but also on its competitors' locations.[1]

Theorem. If the times at which viewers reach home are continuously distributed on an interval $[0, T]$ and if there are at least two broadcasters, then there is no pure strategy Nash equilibrium in broadcast times.

Proof: There cannot be a Nash equilibrium in which any stations broadcast at time 0, since any station at time 0 would have no audience, while at any other time it would have some audience.

There cannot be a Nash equilibrium in which two or more stations broadcast simultaneously at $t > 0$, since if any one such station were to advance its broadcast by an arbitrarily small amount, it would capture almost all of the market that was previously divided equally among the stations that shared its time.

[1] In particular, let $F(T)$ be the number of people who arrive home from work by time T. Then for two stations, X and Y, with locations x and y, the problem is:

For X: $\text{Max}_x\ N^x(x, y)$
For Y: $\text{Max}_y\ N^y(x, y)$

where N^x and N^y are the audience sizes for X and Y, respectively.
In particular, for X:

$$N^x(x, y) = \begin{cases} F(x) & \text{if } x < y \\ F(x) - F(y) & \text{if } x > y \\ \tfrac{1}{2}F(x) & \text{if } x = y \end{cases}$$

and similarly for Y.

There cannot be a Nash equilibrium in which some firm broadcasts alone at a time $t < T$ since such a firm could increase its audience by delaying its broadcast by a small amount of time.

It follows that the only possible pure strategy Nash equilibrium has one station broadcasting at time T and no other stations broadcasting.

Directional constraints have important implications for the existence and nature of equilibria. Here we show that there is no pure strategy Nash equilibrium in continuous time. Elsewhere we have shown that in a Stackelberg model, the only equilibrium has stations dividing the market into equalized shares;[2] furthermore, if time is measured in discreet intervals — if broadcasts are only scheduled on the hour and half hour for example — a Nash equilibrium exists only under very limited circumstances.

In addition to television news scheduling, other situations may usefully be modeled as location problems with directional constraints. The scheduling of airline departure times is one example. In particular, a business traveler may want to take the latest possible flight in the morning that arrives at her destination by a specific time; the traveler will take the flight closest to the preferred time and *not later*. As in the case of news scheduling, airlines have two opposing objectives. On the one hand, an airline would like to schedule flights as early as possible to maximize its potential number of passengers; yet, the earlier the flight is scheduled, the greater the opportunity for a competing airline profitably to offer a later flight.

III. CONCLUSION

The naive strategies implied by the games discussed above are far from realistic; television news schedules are not constantly changing. Nonetheless, anecdotal evidence[3] suggests that some insight can be gained from models that focus on directional constraints.

[2] Cancian, Bills, and Bergstrom [1993].

[3] See, for example, *Broadcasting* (1986), which discusses competitive timing decisions of the major network news broadcasts in Los Angeles.

ACCEPTED AUGUST 1994

MARIA CANCIAN
La Follette Institute of Public Affairs,
University of Wisconsin,
1225 Observatory Drive,
Madison,
WI 53706, USA.

ANGELA BILLS
Department of Economics,
Hampton University,
Hampton,
VA 23668,
USA.

and

THEODORE BERGSTROM
Department of Economics,
University of Michigan,
611 Tappan Street,
Ann Arbor,
MI 48109,
USA.

REFERENCES

Broadcasting, 1986, 'KCBS-TV Moves Network News', Vol. 110:22, pp. 60–63.

CANCIAN, M., BILLS, A., and BERGSTROM, T., 1993, 'What Time is News Time? Hotelling Location Problems and Television News Scheduling', unpublished paper.

HOTELLING, H., 1929, 'Stability in Competition', *Economic Journal*, Vol. 39, pp. 41–57.