Research in Transportation Economics xxx (2017) 1–10

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

Economic analysis of tariff integration in public transport☆

Takaaki Takahashi

Center for Spatial Information Science, The University of Tokyo, 5-1-5, Kashiwa-no-ha, Kashiwa, Chiba 277-8568, Japan

ARTICLE INFO

Article history:
Received 22 December 2016
Received in revised form
16 July 2017
Accepted 11 August 2017
Available online xxx

JEL Classification:
R41
R48

Keywords:
Common fare
Congestion
Distortion in consumers' choices
Distribution of wage
Economies of scale
Tokyo's subway system

ABSTRACT

In this paper, we examine the effects of integrating the tariffs of public transport operated by various institutions on the welfare of economy based on a simple model with users and operators of public transport. Special attention is paid to two benefits of tariff integration; the removal or alleviation of a distortion in consumers' choices, which arises when a shorter route costs more, and the economies of scale in production.

1. Introduction

In many countries, especially in developed ones, the attempts to integrate public transport are becoming more and more widespread (see the report commissioned by the European Commission, NEA (2003), among others).[1] One of the most important elements in the integration is a tariff.[2] A simple type of tariff integration takes the form that different operators adopt the same pricing scheme: several bus companies charge the same fare for a single ride, or several train companies charge the same fare for a trip of a given distance, for instance. In broader integration, this same pricing scheme applies even to the multi-leg services involving more than one operator. That is, the fare for a trip with a given distance is the same whether one uses only the service of one operator or mixes the services of different operators. What we observe most often is this broader type of integration combined with a flat fare. In most of European big cities, for example, they sell the tickets valid for the unlimited number of rides on subways, trams and buses, possibly run by different operators, within a predetermined time period, say 1 h or 1 day.

The aim of this paper is to study the effects of the tariff integration upon the welfare of an economy. Of the various benefits of the integration, only one has been attracting the interests of researchers, namely, the benefit associated with the increase in ridership due to the reduction of transaction costs (for reviews, see White (1981), Carbajo (1988), and Gilbert and Jalilian (1991)).[3,4] However, two other benefits are no less important. In this paper, we pay special attention to these two benefits. One is a removal or alleviation of the distortion in the choices of the users of public transport. The users decide their routes taking into account not only fares but also other

☆ I appreciate the comments from the anonymous referees. I also thank seminar participants at various institutions for helpful discussions. This research is partly supported by the Grants in Aid for Research by the Ministry of Education, Science and Culture in Japan (No. 25285070).

E-mail address: takaaki-t@csis.u-tokyo.ac.jp.

[1] One reason is arguably the growing concerns for environmental issues: the integration is expected to improve the accessibility to public transport and thereby to induce the shift from automobile to it.

[2] Three fields of integration are distinguished (see Abrate, Piacenza, and Vannoni (2009)): informative integration, which provides users an easier access to the information on total networks, timetables and fares; physical integration, which improves the infrastructure necessary to use the services of different operators or those by different modes; and tariff integration, which is a topic of this paper.

[3] In many cases, tariff integration reduces the transaction costs not only directly but also indirectly: the integration is often realized with the help of a brand-new fare collection system accompanied by electronic cards with or without IC chips, which greatly facilitates the usability of public transport.

[4] See Taylor and Carter (1998), Lee (1999), Hirsch, Jordan, Hickey, and Cravo (2000), Giuliano, Moore, and Golob (2000), and Ungemah, Malaika, and Stuart (2006) for the cases in the United States; Dargay and Pekkarinen (1997) in Finland; FitzRoy and Smith (1998, 1999) in Germany and Switzerland; Matas (2004) in Spain; Abrate et al. (2009) in Italy; and Sharaby and Shiftan (2012) in Israel.

http://dx.doi.org/10.1016/j.retrec.2017.08.001
0739-8859/© 2017 Elsevier Ltd. All rights reserved.

factors such as the total lengths of time involved in trips. If tariffs are not integrated, a user may choose a less expensive route even though there is a better route for her in terms of other factors than price. If they are integrated, however, she will pay the same amount of money regardless of the routes to take, and consequently, choose the route that is most desirable for her, for instance, the route with the least amount of time involved. In this way, the tariff integration, inducing users to commit themselves to take the most desirable route of their own, can get rid of a distortion in their choices. Furthermore, if not a small number of users switch to a certain route due to tariff integration, the firm who provides transport service along that route can take advantage of economies of scale in production more after the integration. This is the second benefit we will consider. Because mass transit systems such as subways and commuter rails usually incur huge fixed costs, the exploitation of scale economics is one of the critical conditions for the profitability of their operations. Of course, this benefit needs to be discounted to the extent that the concentration of passengers invokes congestion.

We construct a simple model with the consumers who are heterogeneous in terms of their income levels and two transport firms each of which possesses its own transport route. The consumers decide which firm's service to use comparing the fares and the amounts of time for a trip. We explore the effects of tariff integration, or the introduction of a common fare, on consumers' surplus and transport firms' profits. In particular, it is shown that if two conditions are satisfied, there exists a feasible way of redistributing incomes and profits that makes no consumer nor firm worse off as a result of the introduction of a common fare. One condition is that the effect of congestion is not too devastating; and the other is that the technology of the firm providing a more "efficient" service exhibits a sufficiently higher degree of scale economies compared to that of the other firm. Our results are general to the extent that they hold irrespective of transport firms' pricing behaviors before the integration, or, in other words, no matter whether and how they strategically interact with each other before it.

Most studies on tariff integration concern the reduction of transaction costs as has been discussed. Two exceptions are worth mentioning. First, Cassone and Marchese (2005) compare the welfare impacts of tariff integration under monopoly pricing and under the benevolent regulation through Ramsey pricing to unveil the distortion caused by a monopolistic behavior. Second, Marchese (2006) examines through a nonlinear pricing approach how consumers' surplus is extracted when tariffs are integrated. However, those studies do not discuss the effects of tariff integration on individual consumers and transport firms.

The rest of the paper consists of four sections. In the next section, we take a look at Tokyo's subway system as an example to casually illustrate how severe the problem of the distortion in consumers' choices can be. Section 3 presents a basic model. In Section 4, we examine the effects of tariff integration on the welfare of consumers and the total welfare (i.e., the welfare of consumers and transport firms). The model is extended to a more complicated case with a simple network of transport routes in Section 5. The last section concludes.

2. An introductory case study of Tokyo's subway system

In this section, we look at the subway system in Tokyo in a little more detail to get a rough image of how severe the problem is. The purpose is not to present a rigorous empirical analysis but to provide a casual observation to motivate readers. Tokyo's subway system is operated by two institutions; the Tokyo Metro, a private company, and the Toei, the sector of the Tokyo metropolitan government in charge of its transport network. Among its 13 subway lines, the Tokyo Metro operates 9 lines, which total 195.1 km in length and carry 6.44 million passengers daily in 2012. The Toei operates 4 lines with total length and daily passengers being 109 km and 2.46 million, respectively, in 2013. The tariffs are not integrated. For one thing, the fare schemes are different. Both operators set fares depending on travel distances and the Tokyo Metro charges a lower fare than the Toei for any given distance. Furthermore, if a user wants to take a route consisting of two or more than two legs, some of which are operated by the Tokyo Metro and the rest are operated by the Toei, she basically needs to pay the *sum* of the fares payable to respective operators.[5] Therefore, such a route becomes relatively more expensive compared to the routes consisting of the legs all of which are run by the same operator. On these two accounts, consumers are often enticed to use a less expensive but less efficient (more time-consuming) route.

Now, let us examine travel times and fares between a pair of stations. Because there are too many subway stations in Tokyo (183 stations) to examine travel times and fares for all possible routes, we focus on a subset of the 29 stations that are served by *both* the Tokyo Metro and the Toei.[6] One reason for picking such stations is that there are at least two routes between these stations. For them, 812 (29 multiplied by 28) origin-destination (OD) pairs can be identified. Assuming that a travel starts at the noon on the September 1st in 2014, we look up the travel times and fares required for the corresponding 812 travel patterns and find the fastest route and the least expensive route for each pattern.[7,8]

The first four columns of Table 1 summarize the basic statistics of the travel times and fares of such routes for the 812 OD pairs. They indicate that the fastest route is faster than the least expensive route by 4.42 min on average, which is equivalent to 25.9% of the average travel time of the fastest route. The least expensive route is, furthermore, less expensive than the fastest route by 25.15 yen on average, which equals 13.4% of the average fare of the least expensive route. In an extreme case in which users always choose the least expensive routes, therefore, the travel time will decline by 25.9% (4.42 min) on average if the fares are equalized for all routes, provided that other factors such as the degree of congestion, the frequency of services and the distance to walk are the same among the relevant routes.

However, the least expensive routes coincide the fastest routes for 353 OD pairs. For the remaining 459 OD pairs, which we call "irregular" OD pairs, the least expensive routes are not the fastest ones.[9] When only the irregular OD pairs concern, the time saving effect becomes much greater. The last four columns of the table show figures for only the irregular OD pairs. The fastest route is

[5] In fact, a transfer discount is applicable provided that certain conditions are met.

[6] Even if a pair of stations have different names, we regard them as one station if the two operators do so in offering an inter-operator transfer discount. Furthermore, 2 stations, Meguro and Shirokane-Dai, are, although served by both operators, not included in the 29 stations, because they run trains on the same tracks between Meguro station and Shirokane-Takanawa station through Shirokane-Dai station.

[7] There are a few travel patterns for which either the fastest route or the least expensive route, or both of them include the legs served by other train companies like the JR East. For the sake of simplicity, we disregard such routes and concentrate on the routes along which every leg is served by either of the two subway operators.

[8] Travel time includes the time to wait for trains' arrivals and, if any, the time to change trains.

[9] We say that these pairs are "irregular" by the following reason. In Tokyo's subway system, like many others elsewhere, there is no faster train service with an additional fee (with only one exception). Furthermore, the speeds of trains are not much different among lines. If the fare schemes were the same for the two operators, therefore, a travel with a longer distance would need more money and more time. Consequently, in this "regular" situation, fare would monotonically increase with travel time.

Please cite this article in press as: Takahashi, T., Economic analysis of tariff integration in public transport, *Research in Transportation Economics* (2017), http://dx.doi.org/10.1016/j.retrec.2017.08.001